Volume L Nos. 1-4

Annals
of the
Missouri Botanical Garden

Volume L
1963

This volume was published January 31, 1964

PUBLISHED QUARTERLY BY THE BOARD OF TRUSTEES OF THE MISSOURI BOTANICAL GARDEN
AND WASHINGTON UNIVERSITY PRESS
ST. LOUIS, MISSOURI

Annals

of the

Missouri Botanical Garden

A quarterly journal containing scientific contributions from the Missouri Botanical Garden and the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botanical Garden.

Information

THE ANNALS OF THE MISSOURI BOTANICAL GARDEN appears four times during the calendar year: February, May, September, and November. Four numbers constitute a volume.

Beginning with Volume 45, 1958:

Subscription Price	$15.00 per volume
Single Numbers	4.00 each

Contents of previous issues of the ANNALS OF THE MISSOURI BOTANICAL GARDEN are listed in the Agricultural Index, published by the H. W. Wilson Company.

Beginning June 1, 1962 the Stechert-Hafner Service Agency, Inc., 31 East 10th St., New York 3, N. Y., became sole agent for Annals of the Missouri Botanical Garden. The Agency handles all subscriptions, all claims beginning with volume 50 (1963) and all requests for back issues. Out-of-print numbers will be reprinted as may be required.

Under the arrangement with the Stechert-Hafner Service Agency, the Agency handles also all purchases of any portion of the Annals subseries known as the "Flora of Panama."

All matters regarding exchange continue to be handled by the Missouri Botanical Garden as in the past.

TABLE OF CONTENTS

Polynesian cottons . . . . S. G. Stephens 1-22

Studies in Araceae . . . . George S. Bunting 23-28

An occurrence of the medullosan seed-fern Sutcliffia in the American Carboniferous
Tom L. Phillips and Henry N. Andrews 29-51

Index of orchid names—1962 . . . . Robert L. Dressler 53-54

General index to Volume L 55

MISSOURI BOTANICAL GARDEN

STAFF

EDGAR ANDERSON,
Curator of Useful Plants

HENRY N. ANDREWS,
Paleobotanist

HUGH C. CUTLER,
Executive Director

CALAWAY H. DODSON,
Taxonomist and Curator of Living Plants

JOHN D. DWYER,
Research Associate

RAYMOND FREEBORG,
Research Associate

TRIFON VON SCHRENK,
Assistant Curator Museum of Economic Plants

OWEN J. SEXTON,
Research Ecologist

GEORGE B. VAN SCHAACK,
Curator of Grasses and Librarian

† ROBERT E. WOODSON, JR.,
Curator of Herbarium

BOARD OF TRUSTEES

President
HENRY HITCHCOCK

First Vice-President
LEICESTER B. FAUST

Second Vice-President
HENRY B. PFLAGER

HOWARD F. BAER
DANIEL K. CATLIN
SAM'L. C. DAVIS
DUDLEY FRENCH (*Honorary*)
JOHN S. LEHMANN
WARREN McK. SHAPLEIGH
TOM K. SMITH, JR.
HARRY E. WUERTENBAECHER, JR.

EX-OFFICIO MEMBERS

GEORGE L. CADIGAN,
Bishop of the Diocese of Missouri

JOHN J. HICKS
President, Board of Education of St. Louis

STRATFORD LEE MORTON,
President of the Academy of Science of St. Louis

THOMAS H. ELIOT,
Chancellor of Washington University

RAYMOND R. TUCKER,
Mayor of the City of St. Louis

Secretary
WALDO G. FECHNER

† Deceased November 6, 1963.

Annals
of the
Missouri Botanical Garden

Vol. L FEBRUARY, MAY, SEPTEMBER AND NOVEMBER, 1963 Nos. 1-4

POLYNESIAN COTTONS[1, 2]

S. G. STEPHENS

ABSTRACT

The presence of species of *Gossypium*, which as a whole are widespread throughout the Pacific Islands, is interpreted as the result of at least three independent introductions, widely separated in time. It is suggested that the earliest introduction brought the ancestral form of *G. tomentosum* Nutt. into the Hawaiian Islands where it is now endemic. The most likely means of introduction would appear to be by oceanic drift from the Middle American mainland. It may have been a relatively late addition to the Hawaiian flora. It is suggested that the wild forms of *hirsutum*, which are widely scattered through Southern Polynesia, were introduced much more recently (i.e., after the differentiation of ancestral amphiploid forms into their separate species). It is difficult to imagine that oceanic drift alone accounts for their peculiarly disjunct pattern of distribution (Caribbean—Central America—Southern Polynesia). The speculation is made that they may have been introduced by early 16th-17th century Spanish expeditions into the Southern Pacific, two of which are known to have carried seeds for planting, and one of which is known definitely to have planted cotton. It is pointed out, also, that the Polynesians' ignorance of the use of cotton as a textile does not necessarily imply an ignorance of its numerous other uses, which are widely known to other cultures both in the Old and New Worlds. The final introductions, by missionaries and early agriculturalists in the 19th century, brought cultivated forms of *barbadense* and *hirsutum* into Polynesia. The mongrelized relics of these introductions are the most commonly found cottons in Polynesia today. S. G. STEPHENS, Genetics Department, North Carolina State College, Raleigh, N. C.

BACKGROUND

The New World cottons, so-called, include all the known species of *Gossypium* which have twenty-six pairs of chromosomes. Two of the species, *G. hirsutum* L. and *G. barbadense* L., have given rise to our modern cultivated cottons which, during the past 150-200 years, have been distributed to all cotton growing regions of the world. Today they are usually grown as annuals: summer annuals in temperate regions, like the U. S. Cotton Belt, which are not frost-free, and winter annuals in tropical regions with a dry winter season (e.g., the Pacific coast of Nicaragua).

It is usually accepted that in pre-Columbian times, all New World cottons, with the exception of certain forms apparently indigenous in Polynesia, were con-

[1] Published with the approval of the Director, North Carolina Agricultural Experiment Station, as Paper No. 1525 of the Journal Series.

[2] Communicated by Edgar Anderson.

fined to the American continents, probably to the frost-free areas of those continents. Early descriptions of cottons used by peoples native to Brazil, the Caribbean and Central America, and later by the first colonists in the same regions, all indicate that they were perennial shrubs or trees. Such forms still exist today in primitive cultivation, as individual "dooryard" types in villages, as escapes in secondary bush around cultivated lands, or, more rarely, in a "wild" state. (The term "wild" implies existence as a component of natural, apparently undisturbed vegetation, capable of indefinite maintenance by seed dispersal in competition with the natural flora. It is obvious that these criteria do not differentiate critically between truly wild and ancient escapes from cultivation.) Such perennial forms usually come into flower only under short-day conditions at a time when they would be killed by winter frosts in temperate latitudes. The ability to flower during long (summer) days and to mature a crop before the first killing frost is essential for the establishment of cotton in temperate latitudes. It is unlikely that annual forms of the New World cottons were in existence in pre-Columbian times, with the possible exception of cottons grown by the Hopi, Zuni, and other tribes in what is now the Southwestern United States.

The distribution of New World cottons throughout the Old World tropics follows closely the patterns of trade and slave routes employed by Portuguese and other European traders and colonists. Today they exist as commensal forms and escapes, *but not in the "wild" state*, in all the regions of the Old World tropics which have been influenced by European trade and colonization. Taxonomically they are still very similar to the commensal forms found in the New World. There is therefore little doubt that their introduction into the Old World dates back no farther than the early sixteenth century.

The foregoing brief account supports the conclusion that the New World cottons originated as arborescent or shrubby perennials somewhere in the American tropics. The fact that one of the species, *G. barbadense*, occurs mainly in South America, less frequently in the circumcaribbean region and rarely in Central America and Mexico, while the other species, *G. hirsutum*, occurs mainly in Central America, Mexico and the circumcaribbean region, suggests that the two species developed in early isolation from each other. The Middle American spinning and weaving techniques were undoubtedly based on *hirsutum* cottons, those of South America on *barbadense* cottons. The relation between the two species and the cultures associated with them remains obscure. It is usually supposed on the basis of cytological and cytogenetic evidence (Gerstel and Phillips, 1958; Phillips, 1962) that the two species had a common parentage, and, in my opinion, there is no compelling evidence at the present time which would require a separate origin (see, however, Kammacher, 1960, for a contrary interpretation.)

The American origin of the New World cottons would seem to be self-evident were it not for the disturbing fact that cottons with the same chromosome number and gross structure are known to have existed in the Hawaiian Islands, Society Islands, the Marquesas and Fiji before they were discovered (or re-discovered) in the latter part of the eighteenth century. How did these cottons become established

on islands so remote from the Americas, *before* the islands had anything more than transitory contacts with European or American voyagers? Alternatively, by what natural means of dispersal could cotton seeds be transported from the American continents to the middle of the Pacific Ocean, arrive in viable condition and establish themselves on several widely dispersed island groups? The cytological similarity and interfertility which exist between the Polynesian and American species suggest a recent dispersal. If this were by natural means, e.g. ocean currents (Stephens, 1958a, 1958b), one is immediately faced with multiplying probabilities, each individually small. Thus, if the probabilities of seeds being established by ocean currents in the Marquesas Islands and in the Society Islands are m and n, respectively, where m and n have very low values, the joint probability is mn, which is extremely small. The shorter the time available for dispersal the less likely that many independent sites would be colonized. On the other hand, if dispersal had taken place over long periods of time, the intervals between independent colonizations would also be longer, and one might expect that each island group would have its own unique species, which in turn would retain only distant affinities with its American relatives. Yet the Marquesas and Society Islands cottons differ only in minor details, and both are so similar to "wild" forms of *hirsutum* in the Caribbean region that Hutchinson, Silow, and Stephens (1947) placed them in the same subspecies.

The one obvious way out of this impasse, namely that the cottons were transported by man from the Americas to *one* of the Polynesian islands, and subsequently from island to island-group, is blocked by two hard facts:

1. There is no indication that Polynesian peoples ever spun or wove cotton, their technology being based on bark cloth and the plaiting of various bast fibers (Suggs, 1960).
2. The possible contacts which have been considered between Polynesia and the Americas involve landings on, or departures from the Peruvian coast. The cotton species native to Peru is *G. barbadense*—not *G. hirsutum*. The nearest relatives of the Marquesan and Tahitian cottons are found in Central America and the Caribbean. Consequently the presence of different species of cotton in Polynesia and Peru cannot be regarded as evidence *for* human contacts between them (contra Heyerdahl, 1953).

Any understanding of the evolution of the New World cottons requires, first, a solution to the problem of the establishment of cottons in Polynesia prior to the voyages of Wallis, Cook, Bougainville and others in the latter part of the eighteenth century. The problem has been rather lightly passed over, both by those who favor an ancient origin of the New World cottons (as far back as the Tertiary period according to Stebbins, 1947) and by those who have entertained the possibility of an origin more recent than the domestication of cotton (Hutchinson et al., 1947). As a junior partner in the latter named publication, I propose to express some second thoughts on this problem.

Hawaiian Cotton ("Mao"; "Huluhulu")

Gossypium tomentosum Nutt., *Gossypium sandvicense* Parl.

This is the only member of the New World group of species which is unknown in a cultivated state. Apparently it is completely confined to the Hawaiian Islands. Several independent accessions of this species collected in Oahu and Molokai have been studied in culture at this institution (N. C. State College) and at the Iguala Station, Mexico. The various accessions, unlike all other New World species which have been studied, show remarkably little variation. Taxonomically, *G. tomentosum* can be most easily distinguished from the other New World species by the form of the staminal column in its flower and the fiber structure of its seed.

1. *Staminal column:* All species of New World cottons, and probably all species of *Gossypium* as a whole, possess flowers in which the arrangement of the stamens in the androecium is basically identical. Transverse sections of the young flower bud show that the stamens are regularly arranged in five double longitudinal rows surrounding the pistil. Within each row the stamens arise in pairs—the structure is superficially similar to the arrangement of florets and spikelets in an ear of corn. The regular arrangement which is clearly expressed in the developing flower bud is more or less modified in the mature flower, depending on the amount of fusion which exists (a) between pairs of stamens and (b) within members of each pair. In all species the bases of the staminal filaments are fused together to form the so-called "staminal tube" surrounding the pistil. In *G. tomentosum*, the basal fused region is short, the apical unfused region, long. As a result, the mature flower has long filaments arising from a short tube, and the orderly columnar arrangement of the anthers is obscured. The members of each pair of filaments are regularly fused *inter se*. Each superficially single filament is in reality double for approximately half its length, bifurcating distally into its component units, each of which bears a single anther. The resulting combination of long *branched* filaments and short staminal tube is a unique feature of *G. tomentosum*.

In *G. barbadense* the basal fused region is long, and consequently the more terminal unfused region, short. The columnar arrangement of the anthers remains clearly visible in the mature flower. Fusion within pairs of filaments is frequent, but apparently not regular. Obvious branching of filaments is uncommon—the double structure is revealed only by the fact that some (superficially single) filaments bear twin anthers. The resulting combination of long staminal tube with short filaments is characteristic of *G. barbadense*.

In *G. hirsutum* the pattern of staminal fusion is much more irregular than in the other two species. In general features it is intermediate between *tomentosum* and *barbadense*. Fusion is regular at the base of the column, irregular and incomplete toward the apex. As a consequence, in the mature flower the filaments are short at the base, long at the apex. Branched filaments are more common than in *G. barbadense*, but they are less frequent and more irregular than in *G. tomentosum*.

The relative length of the staminal filaments, whose developmental interpretation has been presented here, was used as a key character by Hutchinson (Hutchinson et al., 1947) in classifying the New World species.

2. *Seed fibers:* All forms of *G. hirsutum* and *G. barbadense,* whether cultivated, commensal or "wild," have their seed fibers differentiated into two layers—a short, strongly adherent coat of "fuzz" fibers* and a long coat of "lint" fibers which can be readily pulled from the seed intact. When dry the lint fibers collapse into flat convoluted ribbons which are easily spun into thread. The structure of the lint fibers also causes them to fluff out from the boll when ripe. Because of this property the unspun fiber is frequently used for stuffing pillows or mattresses, in fact, this is the more common usage of commensal cottons throughout the Caribbean and Central America today.

In *G. tomentosum,* the seed fibers, though convoluted, are not differentiated into fuzz and lint, and they are strongly adherent to the seed coat. It is practically impossible to remove the fibers from the seed without breaking them. Furthermore the fibers tend to remain appressed to the seed and do not fluff appreciably when dry. It is most unlikely therefore that the seed fibers of this species have ever been used by man. They are utterly unsuitable both for textile purposes and for bedding.

The Origin of G. Tomentosum

It is not generally realized that cottons have been used by man for purposes other than those associated with their seed fibers. The Bahia Indians of Brazil (Soares de Souza, cited by Sauer, 1950) used the seeds to make a kind of porridge (*mingau*). Their use as a famine food in India has been inferred by Ramanatha Ayyar (1962) from a study of vernacular and ancient names for cotton. Burkill (1935) mentions various medicinal uses of the leaves (for fevers, dysentery, colic, and as a lactagogue) and roots (diuretic, emmenagogue, and abortifacient). Sir Hans Sloane (1725) listed a variety of uses concerned with internal and external medication, anti-haemorrhagic, etc., employing most parts of the plant. The Caribs in the West Indies used a decoction of cotton leaves in a ritual bath given to their women after child-birth (Hodge and Taylor, 1957), and a similar custom, without the ritual, is probably employed in the more remote Haitian villages today.

There seems to be no record of similar uses in Polynesia, though one might have thought that a people who suffered acute population pressures, practiced infanticide and knew plants, would have experimented with a potential abortifacient. Apparently the flowers of *G. tomentosum* were used as a source of green dye (Bennett, 1840; Malo, 1903; Stephens, in press). However, granting this and other possible uses, there is a compelling reason for believing that man played no significant part in the distribution of this species. This stems from the simple fact that *G. tomentosum* is confined to the Hawaiian group, presumably the *last*

* Mutant forms are common in which the fuzz layer is missing or restricted to a small tuft at the apex of the seed.

group settled in the Polynesian migrations (Suggs, 1960). If *G. tomentosum* had been used and distributed during these migrations, one might expect it to occur with breadfruit, sweet potato, etc., throughout the Polynesian triangle, or alternatively to be concentrated near the *origin* of the migratory routes.

The most likely means of natural dispersal is by seeds carried by ocean currents. Seeds of certain "wild" species of *Gossypium* are capable of floating on sea water for long periods of time with no apparent loss of viability (Stephens, 1958b and unpublished). Many years ago Guppy (1906) concluded that the seeds of *G. tomentosum* were not buoyant enough to be transported in this fashion. However, his observation does not exclude the possibility that the seeds could be transported on "natural rafts" (cf. Murphy, 1926). One successful passage would be sufficient, and the presence of *G. tomentosum* as a coastal plant "on all the islands" (Hillebrand, 1888) is consistent with an early introduction by drift. There is some reason for supposing that certain plants now established in Hawaii arrived by such means (Hillebrand, 1888; Guppy, 1906; Merrill, 1945). Heyerdahl (1953) cites several references which indicate that in the past the inhabitants of Hawaii were accustomed to building their canoes from floating logs brought down by drift from the Pacific Coast of North America. The presence of this "established route" of communication is of particular interest since the Pacific Northwest is known to have supported in Tertiary times a tropical woody flora having affinities with present day genera in Central America. This flora persisted until the onset of a long cooling period during the Oligocene epoch (Chaney, 1947). Stebbins (1947) has, in fact, suggested that the New World cottons are very ancient polyploids which originated in North America in the early part of the Tertiary period "and spread southward from this center, as well as out onto the Pacific Islands." On this interpretation *G. tomentosum* would have been one of the earliest arrivals in Hawaii because, according to Wenthworth (1927), there "appears to be no physical evidence to indicate the emergence of any part of the Hawaiian group above sea-level before the later part of the Tertiary period."

Although at first sight Stebbins' interpretation might seem to agree very well with the paleobotanical record, there are several objections which appear to be pertinent. First, the postulated North American origin of the New World cottons is entirely hypothetical—Merrill (1954), with the same information at his disposal, noted that "the distinctly larger number of species that occur in the southern Pacific region, as compared with those of the northern Pacific" makes a southern connection (*via* Antarctica) more plausible. Second, according to Stebbins' interpretation the separation of *G. tomentosum* from its mainland relatives must have taken place no later than the Oligocene epoch. This implies mutual isolation for at least forty million years without loss of chromosome homology or interfertility. While it is true that there are several instances of disjunct or vicarious species showing remarkably little differentiation over long periods of time, it seems unlikely that this situation would exist where one of the isolates was an *early* and stray colonizer of a group of remote volcanic islands. On the contrary, relaxed selection, lack of competition and the availability of a multitude of

ecological niches would be expected to favor extremely rapid evolution and a pronounced tendency for the development of distinct island forms. This has certainly been true in the case of the Galápagos finches and tortoises, which have evolved in isolation to a degree that their affinities with their mainland "relatives" are obscure. It has also been true in the case of the wild cottons of the Galápagos (*G. darwinii* Watt=*G.barbadense* var. *darwinii* Hutchinson) where there is considerable variation from island to island, and a degree of differentiation from their mainland relatives which renders their taxonomic status rather questionable. This situation contrasts sharply with that of *G. tomentosum* in Hawaii which, judging by the accessions studied in culture, shows remarkably little variation. Finally, a successful colonization in pre-Oligocene times seems unlikely in view of the geological history and floral composition of the Hawaiian Islands. Continued volcanic activity during the Tertiary period was followed by partial submergence in the Pleistocene. During the latter period, according to Stearns and Vaksvik (1935), "a gradual submergence of Oahu by more than 1200 feet resulted in a drowning and sedimentation of the valleys." Fosberg (1951) considered that the American element amounted to only about 16 percent of the total Hawaiian flora, and that more than half of this amount consisted of species closely related to or identical with mainland forms. He concluded that the American element generally is a comparatively late addition to the Hawaiian flora.

From these considerations one may conclude that the presence of *G. tomentosum* in Hawaii cannot be satisfactorily attributed to recent dispersal by human agency, nor is it likely that this species was derived from an ancestral mainland form prior to the Pleistocene period. In my opinion the most logical hypothesis is that considered by Hillebrand (1888) in discussing the general problem of the American element in the Hawaiian flora as related to oceanic drift:

> "The Hawaiian group lies entirely within the domain of the Northeasterly Current of the Pacific . . . which . . . returns upon its course to deposit driftwood of pine logs from the northwest coast of America on the shores of our islands and those of the Marshall and Caroline Islands much farther on. As a review of the Hawaiian flora shows that the northwest coast of America, including California, has until quite recent times only contributed one or two inhabitants of the highest mountains, and has besides few so-called representative species, the influnce of the current in supplying the islands could hardly come into account if it were not for a feeder which it receives on its southern boundary, while deflecting westward, from the coast of Mexico and Central America, and perhaps from still farther south. This accessory stream may or may not account for the important American element of the Andine regions which is apparent in the Hawaiian flora."

Since, as has been pointed out earlier in this paper, the New World relatives of *G. tomentosum* in pre-Columbian times were in all probability confined to the American tropics, north and south of the Equator, it seems possible that seeds of the ancestors of *G. tomentosum* may have reached Hawaii *via* the "feeder" current no earlier than Pleistocene. The fact that this species has not differentiated into distinct island forms nor established itself in a variety of habitats may be taken to suggest that it was a comparatively late arrival in a terrain where most of the available niches were already occupied by earlier migrants. From the meager

evidence presently available there is no necessity for supposing that the primary differentiation of the New World cottons took place outside the limits of the American tropics nor in the remote past. Their geographical distribution prior to the sixteenth century suggests that their common ancestor once occupied the drier and possibly coastal areas within the American tropics. (Wild forms of *G. hirsutum* and *barbadense* occur commonly along the beaches and around natural salt ponds). The first step in their speciation may have been the dispersal of seeds *via* the "feeder" current to Hawaii, the resulting isolate being represented today by *G. tomentosum*, which taxonomically is sharply distinct from both *G. barbadense* and *G. hirsutum*. The next step may have been the geographical isolation of a Central American group, the future *G. hirsutum*, from a South American group which later differentiated into *G. barbadense* and the Galápagos cotton, *G. darwinii*. Hutchinson et al. (1947) reduced the Galápagos form to a sub-species, *G. barbadense* var. *darwinii*, and though its taxonomic status remains, perhaps, controversial, there can be little doubt that its affinities are closer to *G. barbadense* than to the other New World species. It has buoyant seeds capable of being transported in viable condition from the Peruvian coast to the Galápagos Islands (Stephens, 1958b). It is likely therefore that the Humboldt Current accounts for its presence and differentiation in those islands, though a later introduction by pre-Spanish visitors (Heyerdahl and Skjolsvold, 1956) remains a possibility.

Recent Introduction in Hawaii

Any investigation into the origin of the Polynesian cottons is liable to be confused by the fact that within fifty years of the European discovery of the islands attempts were made by missionaries and others to establish spinning and weaving. Consequently, at intervals during the nineteenth century, modern cottons were introduced from a variety of sources; the obviously mongrelized types which now exist as commensal forms throughout the Pacific are presumably the survivors of such introductions.

In Hawaii the earliest attempts at cotton production began around 1812. Cotton was grown for export as early as 1817 (Morgan, 1948). In the 1850's and during the American Civil War, Sea Island cottons were grown. An attempt to revive a flagging industry was made in the early 1900's, and trial plantings of "Caravonica" (from Queensland), Sea Island, and American Upland (from China) were grown successfully (Krauss, 1909). According to Crawford (1937) the industry did not survive for more than two decades. The commensal perennial forms still common on Kauai, Oahu, Molokai, Lanai, Maui and Hawaii are undoubtedly the relics of this former industry. Those which I have found growing on these islands or have studied in culture are similar to the South American commensal forms of *G. barbadense*, except that their seed fibers are often long and silky instead of short and coarse. This would be expected if they are hybrid derivatives of Sea Island and "Caravonica" ancestry, both of which were grown as perennials under Hawaiian climatic conditions. The kidney-seeded forms (*G.*

barbadense var. *brasiliense* Hutchinson), once common on the islands (Krauss, 1911) are very rare today, though the effects of their ancestry are seen in the occasional "semi-kidney" types which may still be found. Five herbarium specimens in the Bernice P. Bishop Museum seem to be representative of the types still extant:

Rock 766, 874 (1908); *Harris C242287* (1924); *St. John 10126* (1929); *Degener 9593* (1933).

Few of the introduced American Upland cottons (*G. hirsutum*) appear to have survived as commensal forms. In the U. S. National Museum is a herbarium specimen (No. 892045) collected by A. S. Hitchcock near Fort Shafter, Honolulu, in 1916, which is clearly a *hirsutum* type. It has copious white lint, and since it was collected "in open ground along a railway car line" it might well be an escape from an earlier planting. In the Bernice P. Bishop Museum is a very similar type (*Degener 24074*) collected in 1956 in Haleiwa churchyard, Oahu. Its round, four-lock boll, small, pale yellow flower, bracteoles deeply gashed but with no more than 9 teeth, and broad and sparsely hairy leaves are characteristics typical of *G. hirsutum*. *Munro 402* in the same collection, recorded as "cultivated cotton, Palawai" has red foliage and "Okra" leaf-shape, both being typical mutant characters of *G. hirsutum*. I have seen only two small colonies of this species in the Hawaiian Islands, both roadside volunteers, behind Kuapa Pond, Oahu, and at the foot of Diamond Head, respectively.

All these *hirsutum* types differ from modern annual Upland varieties in their more slender stems and petioles and generally more woody texture. The living specimens seen were perennials, resembling closely certain commensal forms of the species which are common in Central America. However, it is clear from the description given by Krauss (1909) that the introduced Chinese American Upland type was only a facultative annual, and that it was grown as a perennial in Hawaii:

> "The plant does not seem to be as well adapted to perennial culture as Sea Island, a number of the plants dying at the end of the first season. Several of the pruned plants, however, are making a fairly vigorous growth and may in time acquire the habit of persisting from year to year."

Failing definite evidence of the introduction of perennial forms of *G. hirsutum* into Hawaii during the nineteenth century, one may presume that these specimens are feral relics of known introductions of Upland varieties.

Tahitian and Marquesan Cottons

The first description of an indigenous Polynesian cotton was made by the botanist, Solander, on Cook's first voyage (Merrill, 1954). He recorded the local name of "Ewawei," and in his botanical description noted that the calyx teeth were long and slender. In most other New World cottons which I have seen in culture, the calyx teeth are missing, undulate, or obtuse. Forms with long calyx teeth are rare, but at least one strain (grown by the Hopi Indians of the southwest-

ern U. S.) possesses them. The same form of calyx as described by Solander was recorded by Parlatore (1866). His description was based on Tahitian "Vavai"; he gave it the name, *G. taitense*, and considered it equivalent to Forster's specimen in the British Museum, labelled "*Gossypium religiosum* from Othaheite." Both he and Merrill (1954) considered the calyx form sufficiently diagnostic for the recognition of a separate species.

Apparently another form of indigenous cotton was present in Tahiti at the time of Solander's visit. This collection, made by Banks and Solander in 1769, and preserved in the British Museum and the U. S. National Herbarium, was cited as *G. purpurascens* Poir. by Watt (1907). It has undulate calyces.

Hutchinson et al. (1947) regarded both forms as varieties of *G. hirsutum* (*G. hirsutum* L. var. *punctatum* Schum.). The indigenous Polynesian cotton grown by Hutchinson was obtained not from Tahiti, but from the Marquesas. A specimen prepared by him in 1939 is in the U. S. National Herbarium (No. 1755218). It has undulate calyces. Two accessions have been studied in culture in this country. One may have been obtained from the same source as Hutchinson's material*; it is not morphologically distinct from his herbarium specimen, except for the presence of fine calyx teeth. A herbarium specimen of this accession is preserved by the U. S. Cotton Division under the number, P. I. 133057. A sub-culture of the same accession, maintained in Raleigh and Jamaica, lacks the teeth. A second accession, P. I. 255574, obtained more recently from Nuku Hiva, Marquesas, through the U. S. Cotton Division, has undulate calyces. It seems therefore that the presence or absence of calyx teeth is of rather dubious value for taxonomic purposes in this case.

Both the Marquesan accessions studied in culture have small seeds (less than 5 mm long) with hard seed coats. The fibers are clearly differentiated into fuzz and lint. The latter forms a sparse covering over the seed coat and the individual fibers are short but finer than in cultivated forms of *G. hirsutum*. They are rusty brown in color and do not adhere firmly together in locks when the bolls open at maturity. These characteristics agree in all particulars with those of the "wild" forms of *G. hirsutum* in the Caribbean. Floral morphology is also strikingly similar, and both Marquesan and Caribbean forms have long styles in contrast to most commensal and cultivated forms of the species. The Marquesan forms have glabrous stems and foliage; Caribbean forms may be either glabrous or hirsute. In culture the Marquesan forms tend to grow as compact bushes, while the Caribbean forms may vary from procumbent (Yucatan) to erect (Haiti). Finally, the Marquesan forms appear to be less drought-resistant than those from the Caribbean.

The specimens in the Bernice P. Bishop Museum, listed below, appear so far as

---

* Records of the U. S. Cotton Division suggest that the primary source may have been a collection in 1929 by A. K. Fisher in Uahuka, Marquesas.

may be judged from preserved material, to be similar to the forms studied in culture.

From Fiji: *Bryan 488* (1924); from Samoa: *Christopherson & Hume 539* (1931); from Society Islands: *Segogne 505* (1926), *Wilder 1137* (1932), both collected on Makatea; from Marquesas: *Brown 762* (1921), *Quayle 1573* (1922), both from Nuku Hiva, and *Mumford & Adamson 341* (1930) from Hiva Oa; Hawaii:* *Lyon 226* (1939) from Ualakaa, Honolulu.

In the U. S. National Herbarium are two specimens of *Gossypium* which are of considerable botanical and historical interest. The first, mentioned earlier in this paper, is the Banks & Solander collection of 1769 (Acc. No. 1276371). It has no flowers and the leaves are poorly preserved, but the boll form and seed characters agree with those seen in the Bishop Museum specimens cited above. The second (Acc. No. 12930) was collected by the U. S. Exploring Expedition, commanded by Wilkes, which visited Fiji in 1840. The sheet is labelled "*Gossypium barbadense*, Feejee Is." but obviously carries a mixed collection. One portion of the material bears a large boll with conjoined (kidney) seeds, which presumably accounts for its identification as *G. barbadense*. The other portion of the material was obtained from a much less robust plant, with the small, deeply gashed bracteoles, small flowers and broad leaves characteristic of *G. hirsutum*. The stem is glabrous and punctate and, the calyx teeth have fine, short points. There are no seeds, and a small boll fragment is not identifiable. Its general appearance is similar to that of the Bishop Museum specimens cited above.

From the limited material currently available it appears that a "wild" form of *G. hirsutum*, with or without calyx teeth, and essentially similar to the "wild" forms of the Caribbean region, may be rather widespread in southern Polynesia and neighboring island groups. To my knowledge only Marquesan accessions have thus far been studied in culture. It would be desirable if herbarium specimens still being collected from the Society Islands, Fiji and other areas in the South Pacific could be supplemented by collections of viable seeds.

The Origin of Polynesian Forms of G. hirsutum

1. *Their presence in Polynesia prior to the mid-eighteenth century voyages of discovery.* Merrill (1954) was the first to realize the full significance of the botanical collections made on Cook's voyages. The list of collections serves as a "control" in determining how many of the species existing in Polynesia today were of ancient establishment, or were introduced during the Polynesian migrations, as compared with the very large number introduced intentionally or accidentally within a short time after European discovery. From the Banks and Solander

* This sheet also carries the number, W9-6, which is the type number of Hutchinson's material in the former E.C.G.C. collection, Trinidad, W. I. In all probability this specimen was taken from a plant growing in culture in the late G. P. Wilder's garden, Ualakaa, Honolulu.

collections which have been recorded, it is clear that the native cotton was already established in the Society Islands at the time of Cook's first voyage. The collections themselves, however, do not provide critical information as to whether the cottons were localized in the Society group or established widely throughout Polynesia. Some evidence on this point is available from other sources. In 1792 Captain Josiah Roberts visited the Marquesas Islands and remained there for almost four months. This was the longest recorded visit to these islands by any European or American ship since their discovery by Mendaña in 1595. Roberts noted that cotton was established on several of the islands, and brought back a sample which he deposited in the Boston Museum. He notes:

> "A few days before Captain Roberts sailed from Resolution Bay, it was discovered, that the island Waitahu, or Christina, produced cotton, superior in fineness to any which they had seen. The natives said that it grew in great plenty on all the islands—." (Roberts, 1795).

According to Rollin (1929) the only recorded visitors to the Marquesas *after* Mendaña and *prior* to Roberts were: 1774—Cook; 1791—Ingraham, Marchand; 1792—Hergest, the "Prince William Henry," and the "Butterworth." None of the visits during this interim period lasted more than a few days, and only Cook's visit could have introduced cotton early enough for it to have become established by 1792. There is no indication in Cook's journal (1775) nor in the account by his botanist, Forster (1777), that plantings were made during the visit. The historical evidence therefore agrees with the botanical record and leads to the conclusion that native cottons of similar type were established both in the Society and Marquesan Islands prior to the arrival of Cook and his contemporaries.

It seems likely, too, that a native cotton was present in Fiji some time before the introduction of cultivated forms. Seemann (1862, 1869) stated quite definitely that cotton was not indigenous in any part of that island group, basing his opinion on two lines of evidence: (1) that there were well authenticated records of cotton being introduced in the early 19th century, and (2) that the Fijians had no native name for cotton. The first line of reasoning is of little value because the known introduction of cultivated forms would not preclude the possibility that native and commercially useless cottons were already established there. In fact, this is implied by the presence in Viti Levu at that time of a form with short, tawny fibers which he erroneously identified with the Hawaiian wild species (see Watt, 1907). The second line of evidence, though plausible, fails to stand critical examination. According to Seemann the local name for cotton was "vauvau ni papalagi," *i.e.*, "foreign *vauvau*," because of its resemblance to the true "vauvau," *i.e.*, the edible *Hibiscus Manihot* L. However, an obviously equivalent name, "vavai" or "ewawei" (Parkinson, 1773) was already in use to describe the *native* Tahitian cotton some 25 years before the earliest known introduction of cultivated varieties.

In support of the probability that cotton was native in Fiji, as well as in the Society and Marquesan Islands, are, first, the two herbarium specimens of apparently "wild" *hirsutum* from Fiji, which have been considered in the previous section,

and, second, a reference to *native* cotton in Fiji by Wilkes (1845, Vol. 3). Wilkes, who visited the Fiji group in 1840, wrote the following passage:

> "We were told by the whites of a native nankeen-coloured cotton: of this we did not get specimens; but we found another, which produces a fine white cotton. They have also the cotton-tree (*Gossypium herbaceum*), which grows to the height of fifteen feet."

A distinction appears to have been intended between an indigenous brown-linted form and later introductions. Fortunately the cottons Wilkes described can be checked against the herbarium specimens collected on his expedition. In the U. S. National Herbarium (Acc. No. 12931) is a specimen labelled "*Gossypium herbaceum.* Coll: Feejee Is." which is quite clearly a white-linted, free-seeded form of G. *barbadense.* As has been noted previously, a second specimen (Acc. No. 12930) is a mixed sample of kidney-seeded *barbadense* and a *hirsutum* type resembling the native "wild" forms of the Marquesan and Society Islands.

Finally, Cook's journal (1775) cites briefly the experiences of previous navigators on Easter Island, and notes that Don Felipe Gonzalez on Nov. 16th, 1770 had found cotton growing there. However, neither of the original accounts of the Spanish visit (translated by Corney, 1908) makes mention of cotton growing on the island, and it seems likely that Cook's information was incorrect.

2. *Early uses of cotton in Polynesia.* Parkinson's comment on the indigenous Tahitian cotton (cited Merrill, 1954) was: "This is a species of cotton of which they have not yet found the use." Merrill considered this to be "a very significant statement" implying either that the plant was unused, or else that whoever had introduced it had not introduced with it a knowledge of spinning and weaving. Perhaps of equal significance was Parkinson's use of the definite article (*the* use, not *a* use). Nor did it occur to other writers of the period (Edwards, 1810; Ellis, 1831) that the cotton plant had uses other than as raw material for spinning! As noted earlier, it had been used for numerous medicinal and minor domestic purposes in both Old and New Worlds, and these collectively must have been sufficient to account for its continued survival as a commensal plant today. However, it must be admitted that the evidence for similar uses in Polynesia is meager —some of it suggestive, none conclusive. The following "possibilities" would seem to be worth further investigation:

(a). Embalming.—T. Henry (1938) in her book "Ancient Tahiti" stated: "The vavai-ma'ohi, or native cotton, is a vigorous plant that grows about 18 feet high and produces coarse cotton upon a center of amalgamated seeds. In former times, it was cultivated and used in embalming the dead." Unfortunately this description can only apply to a kidney-seeded form of *G. barbadense,* almost certainly an early European introduction and quite definitely unrelated to the native cotton discovered on Cook's first visit to Tahiti. The missionary Ellis' account of embalming (Ellis, 1831) makes no mention of the use of cotton.

(b). Lampwicks.—Wilkes (1845, Vol. 2, Chap. 2. Tahiti and Eimeo) mentioned the use of the *wild* cotton fiber as a lampwick: "The lamps, which are always kept burning in their houses at night, are made of the shell of a cocoa-nut. The

wick is formed of wild cotton, and is kept upright in the center of the bowl by two elastic strips of cocoa-nut leaf crossing each other at right angles." Henry (1938) states, however, that the cocoanut lamp and the cotton wick were inventions of the early English missionaries (*i.e.*, after *cultivated* cottons had been introduced). If Henry's account is correct an explanation has to be found for the fact that an essentially similar lamp ("moli"), but with a strip of tapa substituted for the cotton wick, was described by Buck (1930) as part of the material culture of Samoa.

(c). Tinderboxes.—Thompson (1845) and Eyriaud des Vergnes (1877) referred to the native use of cotton for tinderboxes in the Marquesas. The latter author distinguished between an *indigenous* cotton, used only for tinderboxes ("Pate"), and introduced cottons of long standing. Thompson, on the other hand, considered all cotton in the Marquesas to be introduced: "It is not indigenous, although it grows in many parts of the islands; when missionaries came here it was found at Naitahu; it is used by the natives to make tinder to light their pipes; natives say it was introduced by a seaman turning out the contents of his bed, which being cotton, contained a few seeds still retaining the vegetating principle." This account of an accidental introduction does not agree with the fact of Roberts finding cotton established there in 1792.

(d). Methods of removing fiber from the seed.—Linton (1923, p. 353) described a hand implement (much like a modern "Swizzle-stick") which was used by the Marquesans to separate the fibers from a mass of seed-cotton. Linton was uncertain whether the implement was an introduction or a Marquesan invention. If an introduction it was a surprising one to be sure, because at the time when the Marquesas were re-discovered in the 18th century modifications of the centuries-old "churka" or Indian roller gin had been in use in the West Indian and former American colonies for at least fifty years. Prior to the use of the roller gin, the fibers were laboriously pulled from the seed by hand, and there seems to have been no implement in use in the New World which in any way resembles the Marquesan tool (O'Neale, 1949).

(e). Polynesian names for cotton.—The native names for cotton throughout southern Polynesia and in Melanesia are remarkably similar:

Fiji—vauvau
Tonga—vavae
Samoa—vavae
Tahiti—vavai
Marquesas—vevai

The Tahitian name is identified with the "wild" form described by Solander, and similar forms have been found in all the other island groups listed above except Tonga. Both the name and the plant with which it is apparently associated are missing from the Hawaiian Islands. There the wild cotton belongs to an entirely different species, *G. tomentosum*, identified with the name "ma'o." This situation is not easily reconciled with Seemann's opinion that the name for

cotton was "borrowed" from a different native genus to describe a new introduction. Why should an identical name-transfer have occurred independently in at least five widely separated island groups? Is it not far more likely that the name was ancient and therefore applied to a native plant, the latter established throughout southern Polynesia, or perhaps even carried from island to island by the Polynesians themselves? The Hawaiian name, "ma'o", describes not the plant itself but the purpose for which it was employed (a green dye). This use has long been forgotten. One wonders whether the name "vavai" may not similarly describe a former, forgotten use. The name itself suggests a reduplication of "vai" or "wai" which is the almost universal name for "water" in Polynesia. In Fiji (Capell, 1941), in Tonga (Churchward, 1959) and in Samoa (Pratt, 1893) the name "wai" or "vai" can be used in a different sense to mean a medicine or potion. There appears to be no evidence whatsoever that the cotton plant was used for internal medication in Polynesia, though it was widely used for such purposes both in the Old and New Worlds.

These scraps of information fall far short of the evidence required to decide whether the native Polynesian cottons were really wild and unused, or whether they formed a minor part of the botanical resources of the Polynesian peoples. The question is an important one. The former interpretation poses a difficult problem in the natural transport of seeds from island to island over vast areas of the Pacific. The latter associates the distribution of the plant with the Polynesian migrations themselves, but raises an entirely new problem regarding the mode, time and place of entry into the Pacific.

3. *A speculation concerning the early introduction of* G. HIRSUTUM *into Polynesia.* There is no *a priori* reason for supposing that the establishment of *G. tomentosum* in Hawaii and the dispersal of the *hirsutum* types throughout Polynesia present a common problem. In the first case one is dealing with the origin of a taxonomically well-differentiated species, but in the second with the wide dispersal of similar forms which differ little from their Central American and Caribbean relatives. This in itself suggests that the *hirsutum* types reached Polynesia considerably later than *G. tomentosum.* Again, the lack of marked differentiation between the several island forms of *hirsutum* suggests that dispersal was rapid and from a common origin, not the cumulative result of individually rare colonizations occurring over long periods of time. Their specific taxonomic affinities with Central American and Caribbean forms suggests one of these areas as their place of origin.

With these considerations in mind I would suggest that the following hypothesis best fits the facts currently availiable.

1. The introduction of *G. hirsutum* into Polynesia from Central America was a unique event which may have occurred as late as the sixteenth or early seventeenth century.
2. The introduced plant was of interest to the Polynesians for purposes unconnected with spinning, and they had distributed it widely, at least through southern Polynesia, before Cook's voyages of discovery.

The "unique event" of the first part of this hypothesis could have been remotely likely arrival of a few seeds drifting onto one or the other of the southern Pacific Islands and establishing themselves as strand plants. "Wild" *hirsutum* plants, in general, are adapted to this type of habitat, and those which have been tested are capable of remaining viable in seawater for long periods. Why the successful migrants should have arrived from Central America rather than South America, remains an enigma. The "wild" cottons of the Galápagos (*G. darwinii*) are equally adapted to salt-water transport, they probably reached the Galápagos Islands from the mainland in this fashion, and they are strategically placed in the path of the Equatorial Current which runs out from South America and through the Polynesian triangle. But the affinities of the Polynesian cottons lie definitely elsewhere.

Merrill (1954) has shown that the floristic affinities of both wild and cultivated plants in Polynesia are overwhelmingly in favor of introduction from southeastern Asia. But there is no known possibility of introduction of any New World species of cotton into this region prior to the Portuguese penetration into the East Indies in the early sixteenth century, and any cottons which they introduced would almost certainly be *barbadense* forms from Brazil, not *hirsutum* from Central America which was entirely under Spanish control. Furthermore, introduction into southeastern Asia at this date would have had to precede Polynesian contacts with the same area, and any such contacts would have introduced spinning techniques along with the cottons.

Land bridges, pre-Polynesian transpacific migrations, "Pacific Regattas," etc., being currently out of favor, I can think of only one other possibility by which a Central American species of cotton could have become established on one or the other of the Polynesian Islands. This turns on the fact that in the late sixteenth and early seventeenth centuries early Spanish voyages were made into the southern Pacific for the purpose of establishing a favorable sea route between Peru and the Philippines. In those days, in the face of increasing rivalry with other European nations, Spain had every reason not to publicize these early attempts. The Manila-Acapulco route was only recently organized on an established basis. There may have been many such voyages—two have been recorded and documented. These are the voyages of Mendaña in 1595 and of Quiros in 1606, accounts of which are available in Markham's (1904) translations. Both these voyages started out with the idea of establishing permanent settlements en route. Both failed in this objective, but settlements were attempted, though subsequently abandoned, in the Marquesas and Santa Cruz Islands in 1595, in the Duff Islands and in New Hebrides in 1606. On both voyages married couples were included as passengers, and seeds for planting in the projected settlements were carried on board. Of the five descriptions of the two voyages which are available in Markham's translations the two narratives of Quiros are the most informative. The first account records that in the Marquesas Mendaña "sowed maize in the presence of the natives." There is a strong possibility that plantings were also begun in the Santa Cruz Islands as the following passages in the same narrative indicate:

"The next time the Adelantado went on shore was to arrange and mark out with the Camp Master a site for a stockade to be used as a fort. Touching this and the ground for sowing, and other matters relating to the administration of the settlement, he had to give his attention and to hear much folly."

And later:

"Others said: We did not come to sow; for that purpose there is plenty of land in Peru—embark us and take us to seek those other islands."

Quiros' narrative of the second voyage in 1606 states specifically that cotton was planted* on Espíritu Santo in the New Hebrides:

"The Captain, on the last day of Easter, taking with him such an escort as seemed necessary, went to an adjacent farm of the natives and sowed a quantity of maize, cotton, onions, melons, pumpkins, beans, pulse and other seeds of our country."

All the attempted settlements were abandoned before there would have been time for any of the plantings to be harvested. But Merrill's (1954) assumption that the plantings failed is perhaps unwarranted. There is simply no evidence on this point. While it is probable that most of the species planted would not survive without attention, the cotton of the time would have been a perennial shrub capable of surviving for ten or more years. It must be remembered also that the accounts of the voyages were not written by an agriculturalist—the narrator was concerned with reporting the administrative problems encountered in founding settlements in the face of opposition from disgruntled crews and hostile natives, and the planting details are merely incidental information. The accounts, therefore, do not necessarily provide a complete planting record. Seeds, including cotton, may have been planted on all the islands visited. If cotton plants had survived they would have been harvested after the Spaniards left, and consequently there would have been no information available concerning the uses of the fiber. This would provide a possible explanation of the presence of the plant in the islands without a knowledge of its spinning techniques.

There are certain objections to the possibility that one or the other of these voyages may have been responsible for the introduction of *G. hirsutum* into the Pacific. Both voyages started from Peruvian ports, and if the seeds were obtained locally they would almost certainly have been *barbadense* types. On the other hand, according to Spanish colonial practice of the time, the voyages had first to be approved by the Casa de Contratación in Spain, which authorized and kept a register of all cargoes including plants and seeds (Hussey, 1934; Haring, 1947). In this situation the seeds which were to be planted might well have been selected before the voyagers left Panama on their way to Peru. A more serious objection stems from the general opinion that the long-distance voyages of Polynesians were drawing to a close before "the advent of the Europeans in the sixteenth century" (Suggs, 1960). Purely local travel between neighboring islands probably could not account for the dispersal of the cottons across the entire base of the Polynesian triangle.

---

* Gasper of Leza's account of the same planting includes "calabashes of Peru" and potatoes, but not cotton.

Recent Introduction in the Southern Pacific

In the nineteenth century attempts were made to introduce a cotton industry to several Pacific islands. In southern Polynesia the earliest introductions appear to have been in the Society Islands in 1801 or soon thereafter (Ellis, 1831). Several "valuable kinds of cotton" were introduced, and it was noted that there was "one variety which appeared to be an indigenous plant in most of the islands." Machinery for spinning and weaving was introduced by the missionaries, but ginning was done by hand. There is apparently no record of the kinds of cotton introduced at this early stage, though Henry's (1938) reference to an early kidney-seeded form, and the prevalence of *barbadense* type of herbarium specimens and seed collections from southern Polynesia suggest that agricultural varieties of this species were predominant.

In the Marquesas the earliest introduction may have been accidental as supposed by Thompson (1845), but culture certainly was attempted at an early date (1838 ?) by Catholic missionaries and by 1870 cotton was grown for export to Tahiti (Eyriaud des Vergnes, 1877). Varieties cultivated at that time included "Fidji," "Sea Island," "New Orleans" and "Georgia" cotton (*i.e.*, cultivated varieties of *G. barbadense* and *G. hirsutum*). The rapid development of cotton culture in mid-nineteenth century was attributable to the temporary shortage of raw cotton during the Civil War (Rollin, 1919). Culture of Sea Island cottons was attempted in Fiji in the latter part of the 19th century as a result of Seemann's optimistic recommendations. Dissemination of cultivated forms to the more remote areas of the Pacific must have proceeded with great rapidity, for by 1836 even the Pitcairn Islanders were growing "the cotton shrub (*Gossypium vitifolium*) loaded with large and globular pods, containing much excellent wool" (Bennett, 1840). This was probably introduced after the return of the islanders from a temporary sojourn in Tahiti. The Polynesian peoples distinguished these new introductions from the older and, in my opinion, native forms by adding the epithet "papalagi" ("foreign") to the original name, or by coining a new name, "puru puru" ("softly downy"), descriptive of the product for which the plants were grown.

With this historical background it is not to be expected that the types surviving today will fall into neat taxonomic categories. Each little island has served as a melting pot in which the characteristics differentiating the original agronomic races have had ample opportunity to become thoroughly recombined, refreshed by occasional interspecific hybridization, introgression with the native forms perhaps taking place as is happening still in the Hawaiian Islands (Stephens, in press). In Oahu today it is difficult to find specimens of "*G. barbadense*" (sensu lato) carrying the same combination of racial characteristics which presumably distinguished the original introductions. Often, different characteristics typical of Kidney, Sea Island and Egyptian type cottons can be seen in one individual or expressed at an intermediate level. There is no reason to expect a different situation in other Pacific islands. It is more realistic to regard the medley of transient escapes, dooryard and roadside forms as members of a common polytypic as-

semblage in which *barbadense* characteristics predominate. Such a concept would easily encompass the following accessions preserved in the berbarium of the Bernice P. Bishop Museum:

Raiatea, Society Islands: *Moore 214* (1926), *564* (1927); Samoa: *Vaupel 253* (1905), *Wisner 100* (1959); Tonga: *Parks 16391* (1926); Fiji: *Smith 6626* (1947); Niue, Friendly Islands: *Yuncker 9858* (1946); Hiva Oa, Marquesas: *Mumford & Adamson 341* (1929); Arno Atoll, Marshall Is.: *Anderson 3685* (1950); Rarotonga, Cook Is.: *Wilder 941* (1929).

Summary and Conclusions

The presence of species of *Gossypium*, which, as a whole, are widespread throughout the Pacific Islands, is interpreted as the result of three separate introductions. A long period of time elapsed between the first and second events.

The first introduction resulted in the establishment and differentiation of a distinct species, *G. tomentosum*, in the Hawaiian Islands. The absence of significant taxonomic or ecological differentiation between island forms of this species and the lack of cytogenetic differentiation between these forms and the related mainland species, *G. barbadense* and *G. hirsutum*, do not indicate an introduction into Hawaii as early as the Tertiary period. More likely, *G. tomentosum*, like other American elements in the Hawaiian flora (Fosberg, 1951), arrived as a relatively late addition to an already established vegetation. The most likely means of arrival would appear to be as drift on the "feeder current" (Hillebrand, 1888) which reaches Hawaii from Central America. It is unlikely that man played any part in the distribution of this species. Its fibers, unlike those of any other members of the New World group of species, are quite unsuitable for spinning or other purposes, for they are difficult to remove intact from the seed. Further, distribution by man is quite at variance with the anthropological evidence that Hawaii was the last of the island groups to be reached by the Polynesians (Suggs, 1960).

The second introduction must have occurred after the differentiation of *G. barbadense* and *G. hirsutum* in tropical America, since its taxonomic affinities lie entirely with the latter species. There is evidence that this Polynesian form of *hirsutum* was widespread in the Pacific (at least from Fiji to the Marquesas) prior to the eighteenth century voyages of Cook, Bougainville and others. The possibility that oceanic drift could account for the whole of this distribution, without producing a Polynesian species distinct from the Central American forms of *hirsutum*, seems barely tenable. It is difficult also to understand why Central America should be the probable source of dispersal rather than the Galápagos Islands, whose "wild" cottons are strategically placed and adapted to oceanic dispersal. It is suggested that although the Polynesian peoples had no spinning and weaving techniques, they may have employed the cotton plant for a variety of other purposes, as are the native cottons in the Americas today. Unless this possibility can be definitely excluded it seems likely that an "unknown rare event" may have introduced the cotton into one or the other of the many Polynesian groups, and that the subsequent

wide dispersal throughout the Polynesian triangle may have been due to human agency. The "unknown rare event" could have been oceanic drift; alternatively, there are records of plantings being made on at least two widely separated Pacific islands during the early Spanish voyages at the turn of the 16th and 17th centuries. If such plantings survived they would have resulted in the introduction of a New World species without the introduction of spinning and weaving techniques.

The third introduction occurred in the early part of the nineteenth century, as the result of attempted introductions of cotton growing and manufacture by early missionaries. At a later date the introduction of modern Sea Island varieties was tried. The commensal types (chiefly *G. barbadense*), which are widespread in the Pacific Islands today, are probably relics of these 19th-20th century introductions and their hybrids.

Acknowledgements

I am greatly indebted to the Bernice P. Bishop Museum and to the U. S. National Herbarium for the loan of specimens to which reference has been made in this article. The framework of reference, against which the taxonomic evaluations have been made, has been a live collection of Caribbean and Central American native and wild forms of *G. barbadense* and *G. hirsutum*, maintained formerly at the Atkins Garden, Cuba, and now at the University of the West Indies, Jamaica. Most of the types studied were collected under the terms of a grant by the John Simon Guggenheim Memorial Foundation, 1959-60. The work is part of a research program supported by a National Science Foundation Grant No. G14203.

Literature cited

Ayyar, Ramanatha. 1962. A few clues on the early use of cotton. Indian Cotton Grow. Rev. 16: 59-65.

Bennett, F. D. 1840. Narrative of a whaling voyage round the globe from the year 1833-1836. London, Bentley. 2 vols.

Buck, P. H. 1930. Samoan material culture. Bernice B. Bishop Mus. Bull. 75. 724 p.

Burkill, I. H. 1935. A dictionary of the economic products of the Malay Peninsula. London, Crown Agents for the Colonies. 2 vols.

Capell, A. 1941. A new Fijian dictionary. Sydney, Austr. Med. Publ. Co. 464 p.

Chaney, R. W. 1947. Tertiary centers and migration routes. Ecol. Monogr. 17: 139-148.

Churchward, C. M. 1959. Tongan dictionary. London, Oxford Univ. Press. 836 p.

Cook, J. 1775. Journal of the "Resolution's" voyage in 1772, 1773, 1774, and 1775. London, Newbery. 328 p.

Corney, B. G. 1908. The voyage of Don Felipe Gonzalez in the ship of the line San Lorenzo with the frigate Santa Rosalia in company, to Easter Island in 1770-1. Cambridge, Hakluyt Soc. 176 p.

Crawford, D. L. 1937. Hawaii's crop parade. Honolulu, Advertiser Publ. Co. 305 p.

Edwards, B. 1810. The history, civil and commercial, of the British Colonies in the West Indies. Philadelphia, Levis & Weaver. 4 vols.

Ellis, W. 1831. Polynesian researches. London, Fisher, son & Jackson. 4 vols.

Eyriaud des Vergnes, P. E. 1877. L'archipel des Iles Marquises. Paris, Berger-Levrault & Cie. 98 p.

Forster, G. 1777. A voyage round the world, in His Britannic Majesty's sloop, Resolution, commanded by Capt. James Cook, during the years 1772, 3, 4, and 5. London, B. White. 2 vols.

Fosberg, F. R. 1951. The American element in the Hawaiian flora. Pacif. Sci. 5: 204-206.

Gerstel, D. U., & L. L. Phillips. 1958. Segregation of synthetic amphiploids in *Gossypium* and *Nicotiana*. Cold Spring Harbor Symp. Quant. Biol. 23: 225-237.

Guppy, H. B. 1906. Observations of a naturalist in the Pacific between 1896 and 1899. Vol. 2. Plant dispersal. London, Macmillan.

Haring, C. H. 1947. The Spanish Empire in America. London, Oxford Univ. Press. 388 p.

Henry, Teuira. 1938. Ancient Tahiti; based on material recorded by J. M. Orsmund. Bernice P. Bishop Mus. Bull. 48. 651 p.

Heyerdahl, T. 1953. American Indians in the Pacific. Chicago, Rand McNally. 821 p.

Heyerdahl, T., and A. Skjölsvold. 1956. Archaeological evidence of pre-Spanish visits to the Galápagos Islands. Mem. Soc. Amer. Archaeol. 12. 72 p.

Hillebrand, W. 1888. Flora of the Hawaiian Islands. London, Williams & Norgate. 673 p.

Hodge, W. H., & D. Taylor. 1957. The ethnobotany of the Island Caribs of Dominica. Webbia 12: 513-644.

Hussey, R. D. 1934. The Caracas Company, 1728-1784. A study in the history of Spanish monopolistic trade. Cambridge, Harvard Univ. Press. 358 p.

Hutchinson, J. B., R. A. Silow & S. G. Stephens. 1947. The evolution of *Gossypium*. London, Oxford Univ. Press. 160 p.

Kammacher, P. 1960. Observations cytologiques sur deux hybrides F_1 entre espèces cultivées tetraploides de cotonniers et l'espèce diploide sauvage *Gossypium raimondii* Ulb. Revue de cytologie et de biologie végétales 22: 1-28.

Krauss, F. G. 1909. A preliminary report on cotton experiments. Hawaii Agric. Expt. Sta. Press Bull. No. 24. 16 p.

Krauss, F. G. 1911. Cotton culture in Hawaii. Hawaii Almanac & Annual for 1911: 58-67.

Linton, R. 1923. The material culture of the Marquesas Islands. Mem. Bernice P. Bishop Mus. Vol. 8, No. 5. 471 p.

Malo, D. 1903. Hawaiian antiquities, tr. by N. B. Emerson . . . 1898. Honolulu, Hawaiian Gazette Co. 366 p.

Markham, C. 1904. The voyages of Pedro Fernandez de Quiros, 1595-1606. Hakluyt Soc. Works. ser. 2, Nos. 14-15.

Merrill, E. D. 1945. Plant life of the Pacific world. New York, Macmillan. 295 p.

Merrill, E. D. 1946. Merrilleana. Chron. Bot. 10: 127-393.

Merrill, E. D. 1954. The botany of Cook's voyages. Chron. Bot. 14: 161-384; pl. 80-93.

Morgan, T. 1948. Hawaii; a century of economic change, 1778-1876. Cambridge, Harvard Univ. Press. 260 p.

Murphy, R. C. 1926. Oceanic and climatic phenomena along the west coast of South America during 1925. Geogr. Rev. 16: 26-54.

O'Neale, L. M. 1949. Weaving, in Handb. South Amer. Indians. Vol. 5. Smith Inst. Bur. Amer. Ethn. Bull. 143(5): 97-138.

Parkinson, S. 1773. A journal of a voyage to the South Seas in His Majesty's ship "The Endeavour." London, Printed for Stanfield Parkinson, 212 p.

Parlatore, F. 1866. Le specie dei cotoni. Firenze, Stamperia reale. Vol. 1 (text), Vol. 2 (plates).

Phillips, L. L. 1962. Segregation in new allopolyploids of *Gossypium*. IV. Segregation in New World x Asiatic and New World x wild American hexaploids. Amer. Jour. Bot. 49: 51-57.

Pratt, G. 1893. A grammar and dictionary of the Samoan language. London Missionary Soc. Publ. 416 p.

Roberts, J. 1795. The discovery and description of the islands called the Marquesas in the South Pacifik Ocean. Coll. Mass. Hist. Soc. [ser. 1] 4: 238-246.

Rollin, L. 1929. Les Iles Marquises. Paris, Société d'éditions géographiques, maritimes et coloniales. 334 p.

Sauer, C. O. 1950. Cultivated plants of South and Central America, in Handb. South Amer. Indians. Vol. 6. Smith. Inst. Bur. Amer. Ethn. Bull. 143(6): 487-543.

Seemann, B. 1862. Viti: an account of a Government Mission to the Vitian or Fijian Islands in the years 1860-61. London, Macmillan. 447 p.

Seemann, B. 1865-73. Flora Vitiensis. London, Reeve & Co. 453 p.; 100 pl.

Sloane, H. 1707-25. A voyage to the islands Madera, Barbados, Nieves, S. Christophers and Jamaica. London, printed for the author. 2 v.

Stearns, H. T., & K. N. Vaksvik. 1935. Geology and ground-water resources of the island of Oahu, Hawaii. Hawaii. Dept. of Public Lands. Div. of Hydrography. Bull. No. 1. 479 p.

Stebbins, G. L. 1947. Evidence on rates of evolution from the distribution of existing and fossil plant species. Ecol. Monogr. 17: 149-158.

Stephens, S. G. 1958 a. Factors affecting seed dispersal in *Gossypium*. North Carolina Agr. Expt. Sta. Tech. Bull. No. 131. 32 p.

Stephens, S. G. 1958 b. Salt water tolerance of seed of *Gossypium* species as a possible factor in seed dispersal. Amer. Nat. 92: 83-92.

Stephens, S. G. (in press). Native Hawaiian cotton (*Gossypium tomentosum* Nutt.) Pacif. Sci.

Suggs, R. C. 1960. The island civilizations of Polynesia. New York, New American Library. 256 p.

Thompson, R. 1845. Marquesan Islands. Part III. The Friend. 3: 30-31.

Watt, G. 1907. The wild and cultivated cotton plants of the world. London, Longmans. 406 p.

Wentworth, C. K. 1927. Estimates of marine and fluvial erosion in Hawaii. Jour. Geol. 35: 117-133.

Wilkes, C. 1845. Narrative of the U. S. Exploring Expedition. Philadelphia, Lea & Blanchard. 5 vols.

STUDIES IN ARACEAE*

GEORGE S. BUNTING

ABSTRACT

Five American species of aroids are described as new to science: *Philodendron barrosoanum*, *P. dressleri*, *P. frits-wentii*, and *P. grazielae*, and *Caladiopsis dodsonii*. One species is transferred to the appropriate genus on the basis of recently collected flowering material, and the new combination, *Epipremnum aureum* (Linden & André) Bunt., is made. George S. Bunting, Bailey Hortorium, Cornell University, Ithaca, N. Y.

PHILODENDRON **barrosoanum** Bunt., sp. nov. Fig. 1.

Caudex scandens internodiis 3-6 cm longis, 4 cm crassis. Cataphylla ca. 35 cm longa marcescens. Foliorum lamina utrinque nitida, hastato-trilobata; lobo antico ovato, secundum costam ca. 40 cm longo, 21 cm lato ad medium, apicem versus angustato, apice ipso acuminato vel obtuso et mucronato, costa valida convexa, utrinque ca. 4 nervis primariis lateralibus; lobis lateralibus fere horizontaliter divergentibus oblique elliptico-ovatis ca. 28 cm longis, latitudine sua

Figure 1. *Philodendron barrosoanum Bunt.*

*From work related to a project supported by National Science Foundation Grant No. G-9799.

dimidio brevioribus, apices versus angustatis, apicibus ipsis obtusis, ad bases lateribus exterioribus rotundatis, costi basilaribus nudis ca. 5 cm in sinu lato-quadrato-companulato. Petiolus teres, ad 74 cm longus, ad medium 1.6 cm crassus. Inflorescentiae ad 4 vel 5 ex eodem loco. Pedunculus 7-10 cm longus, apicem versus notis numerosis atropurpureis. Spatha ad 18 cm longa marginem versus translucida 4-7 mm; tubo subinflato lamina subaequilongo, extus viridi pallido cum notis atropurpureis, intus roseokermesino; lamina extus flavidescenti cum notis parvis numerosis rubris. Spadix spatha aequans, breviter stipitatus; parte staminata 9 cm longa cum parte fertili clavata basim versus angustata, parte sterili subcrassiore. Flores pistillati breves vix longiores quam crassis, ovaribus 8-11-locularibus, loculis 5(4-6)-ovulatis, ovulis fasciculatis axillaribus super basim.

Type collection: *G. M. Barroso s.n.* (designated 60R9), cultivated in Jardim Botânico do Rio de Janeiro, April (?) 1960. "Não escandente. Espata verde, atropurpurea externamente, com a base purpurea internamente. Amazonas." [HOLOTYPUS MO].

Additional specimens: Cult.: in Jardim Botânico do Rio de Janeiro, (without date) 1960, *G. M. Barroso s.n.* (designated 60R16) [MO]; in greenhouse, Missouri Botanical Garden, Feb. 1960, *Bunting 251* [MO]; BRAZIL: Pará: região do Arriamba; mata, tronco caído, 1. 6. 1957, *W. A. Egler 438* (MG no. 22.046) [MG].

I would have preferred to designate *Egler 438* as type, but the specimen, consisting of a single leaf subtending inflorescences, has narrower lateral lobes of the leaf, and the basal sinus is more spreading than in the cultivated material. The form of the sinus is an outstanding feature of the plants in cultivation.

P. barrosoanum has been in cultivation for several years, often under the name *P. deflexum*, to which it appears to be closely allied. *P. deflexum* Poeppig ex Schott is a Peruvian species of very different leaf form, having an elongate-oblong anterior lobe and short, narrow lateral lobes.

The specific epithet honors Graziela M. Barroso, Chefe da Secção da Botânica Sistemática, Jardim Botânico do Rio de Janeiro, and a student of the Araceae.

PHILODENDRON **dressleri** Bunt., sp. nov. Fig. 2.

Caudex scandens ca. 7 cm crassus, internodiis stirpis adultae 4-6.5 cm longis vel brevioribus. Foliorum lamina membranacea (siccitate), in ambitu ovata, bipinnatifida, ad 86 cm longa 66 cm lata, sagittata; lobo antico pinnatifido utrinque 6 segmentis 3-5-lobatis; lobis posticis ca. 5-segmentis; costa plana vel apicem versus convexa, nervis lateralibus primariis convexis; costulis posticis in sinu subrhombico 2-4 cm nudis. Petiolus teres, ad 70 cm longus, vaginatus (in stirpe florifera) in tertia parte inferiore. Pedunculus 13-16 cm longus. Spatha extus obscure viridis, 18-21 cm longa, leviter constricta infra medium, tubo 4.5 cm crasso intus saturo kermesino, lamina intus rosea. Spadix stipitatus, parte pistillata 3.5 cm longa, 2.2 cm crassa; parte staminata 11 cm longa, parte sterile 3 cm longa 2.4 cm lata et fertile clavata super 2.4 cm crassa infra 1.9 cm crassa, ad apicem obtusata paucis floribus sterilibus; stamina 4 mm longa; pistilla oblonga ad 7 mm longa in aetate, 4-5-locularia, ovulis in loculis 3-4-biseriatis.

Figure 2. *Philodendron dressleri* Bunt., the plant from which the type specimens were prepared *(Moore & Bunting 8688)*.

Type collection: *Moore & Bunting* 8688 collected in MEXICO: Nayarit: on road to San Blas, 14-16 miles SW of junction with Highway 15. "Huge epiphyte on *Orbignya guacuyule;* stems 7 cm diam.; petioles terete, 1.8 cm across at mid-point; inflorescences borne singly, spathes dark green outside, inside blade rose punctate darker, tube dark cherry-red; spadix 3.5 cm shorter than spathe." [HOLOTYPUS BH, isotypes K, US, MO].

Distribution: MEXICO: coastal Nayarit to southern Sinoloa.

MEXICO: Nayarit: W of Jolcocotan, Dec. 1949, *R. L. Dressler 1051* [UC]; about 6 miles S of Mazatán, July 1961, *Dressler & M. Wirth* 2732 [MO, BH]; María Madre, Tres Marias Islands, alt. 1000 ft., Oct. 1925, *Roxana S. Ferris* 6249 [US]; near Singaita, E of San Blas, Dec. 1954, *R. N. Philbrick 414* [BH]. Sinaloa: Mazatlán, July 1934, *J. Gonzales Ortega* 7393 [F, US] (juvenile, probably referrable here); Cañada La Calera, Municipalidad Concordia, alt. 200 m., Sept. 1919, *Clemente Trejo 1112* [US].

A specimen from Culiacán, Sinaloa, *J. Gonzalez Ortega* 6632 [US], consisting of a single leaf, may be referrable to this species, but needs to be re-collected.

Closely allied to *P. warscewiczii* C. Koch, *P. dressleri* is easily recognized by its much less deeply lobed leaf-blades, pinnatifid only about halfway to the mid-rib. In *P. warscewiczii*, blades are cleft nearly to midrib. The latter species is widely distributed in Central America, apparently reaching its northern limit in Jalisco, Mexico, some 150 miles to the south of the known range of *P. dressleri*.

The species name honors Dr. Robert L. Dressler. His extensive Mexican collections include the first flowering specimens of *P. dressleri*, and he is responsible for introducing this species into cultivation in this country.

Philodendron **frits-wentii** Bunt., sp. nov. Fig. 3.

Caudex scandens, internodiis elongatis. Foliorum lamina in ambitu ± campanulata, ca. 10.5 cm longa, 11 cm lata, ad apicem acuminata, ad basim cordato-sagittata vel lobis posterioribus leviter patentibus, crasso-fragilis, supra subconcava, costa et nervis primariis numerosissimis haud prominentibus, infra pallida, nitidissima. Petiolus 14.5-17.5 cm longus, fere teres apicem versus, basim versus deplanatus ventraliter, ad basim late vaginatus per ca. 1.5 cm, in stirpe juvenili fere medio usque vaginatus. Inflorescentiae solitariae vel geminae, pedunculo 3 cm longo. Spatha flavido-alba, 4.2 cm longa, 7 mm crassa, fere cylindrica. Spadix quam spatha leviter longior, parte staminata quam pistillata vix longiore. Ovaria 4-5-locularia, loculis uniovulatis.

Type collection: *Bunting 273*, cultivated in greenhouse at Missouri Botanical Garden, May 1960. [holotypus MO]. Origin unknown. Apparently not in general cultivation.

P. frits-wentii belongs to section *Oligospermium* Engler. It is nearly allied to *P. grazielae* Bunt.

The species is named to honor Dr. Frits W. Went, eminent physiologist, ecologist, and friend of horticulture, till recently director of the Missouri Botanical Garden.

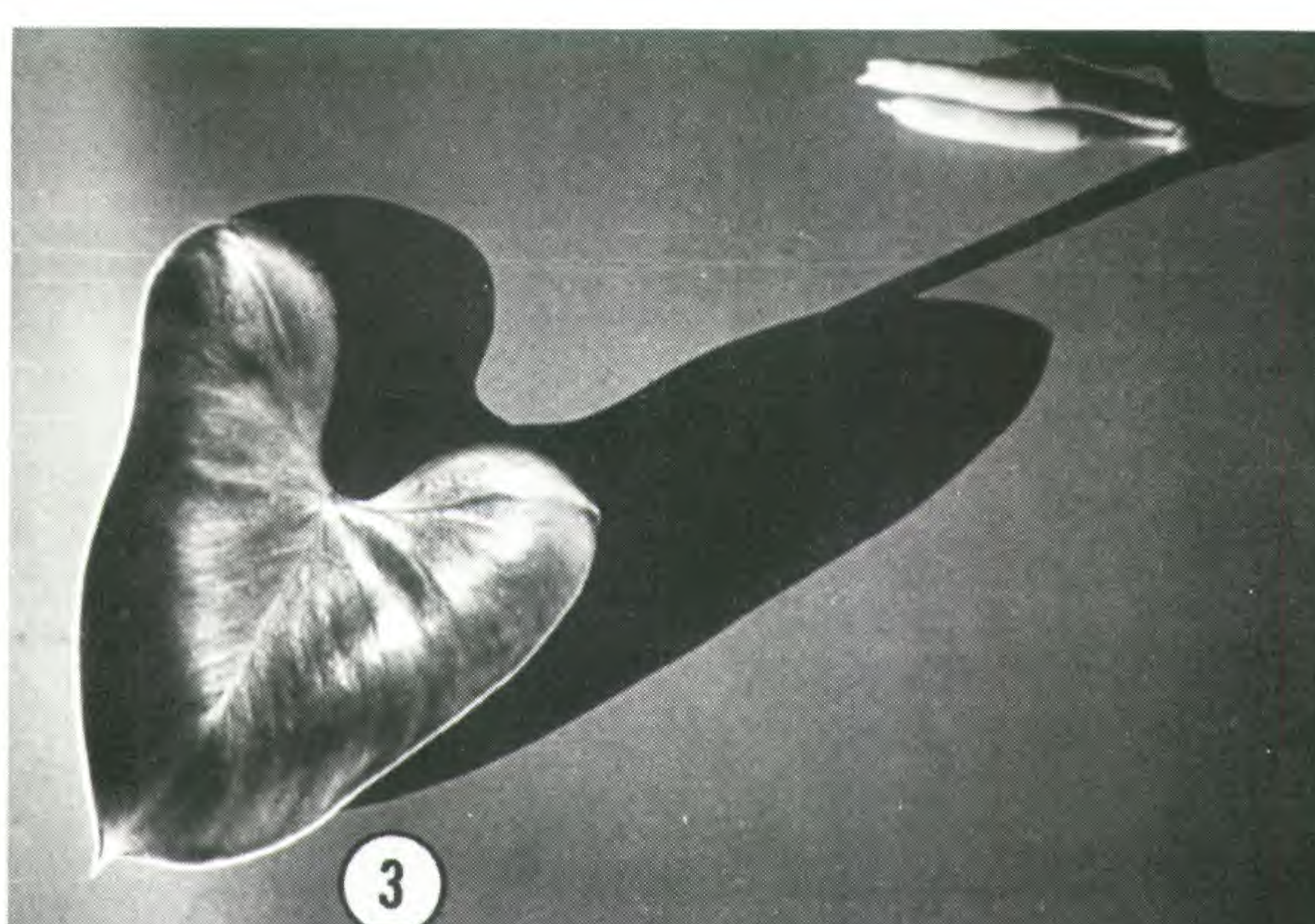


Figure 3. *Philodendron frits-wentii* Bunt.

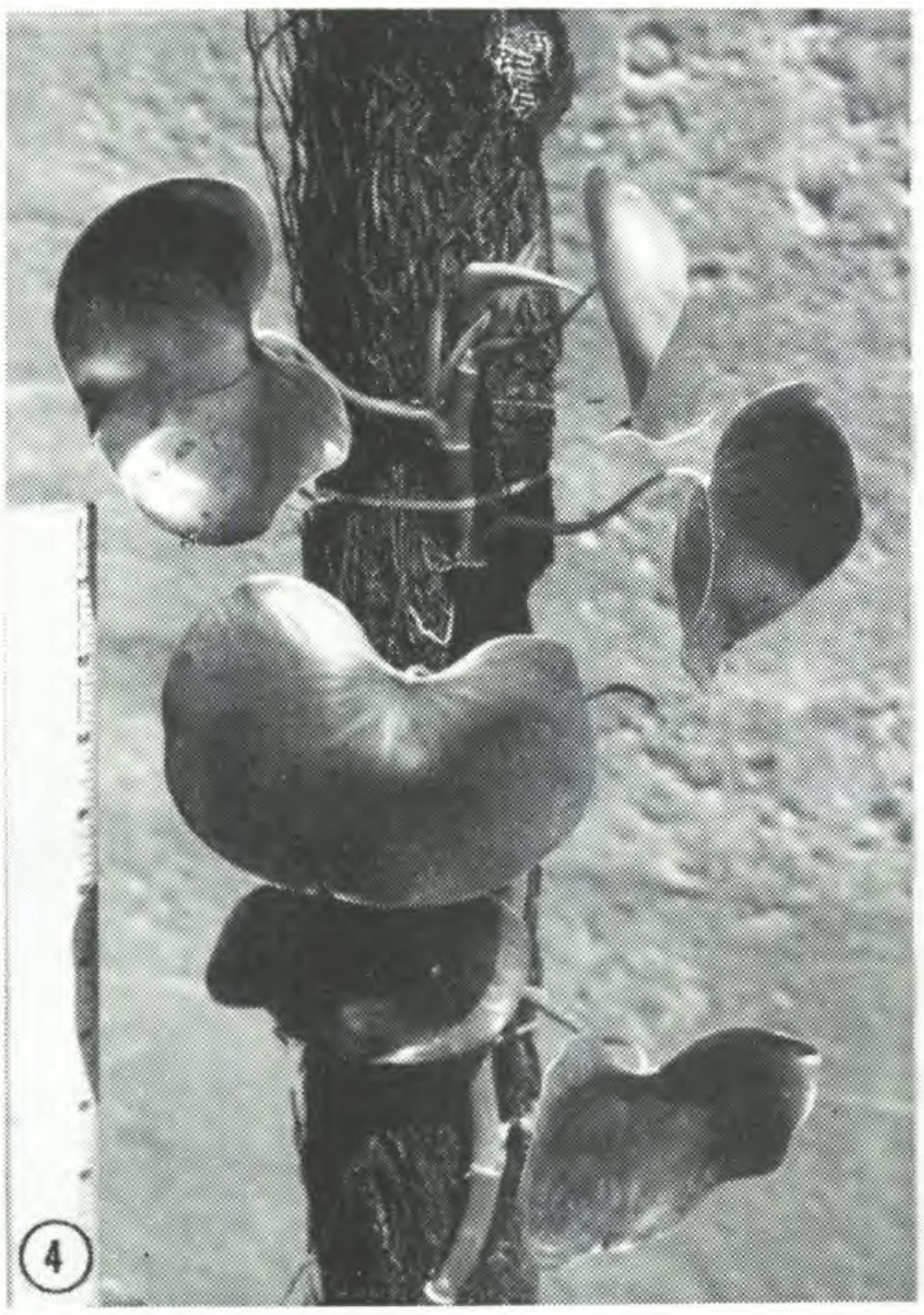


Figure 4. *Philodendron grazielae* Bunt.
Figure 5. *Caladiopsis dodsonii* Bunt.

PHILODENDRON **grazielae** Bunt., sp. nov. Fig. 4.

P. fibrillosum Hort. non Poeppig.

Caudex scandens internodiis 4-5 cm longis. Foliorum lamina coriacea, nitida, subreniforma abrupte subcaudata ad basim cordata, 9.5-11 cm lata, subaequilonga cum apice reflexo (fere 2 cm longa), sinu campanulato 2-2.5 cm profundo; costa et nervis primariis numerosis subaequalibus vix prominentibus. Petiolus quam lamina leviter brevior, teres, vaginatus 1 cm in foliis cum inflorescentiis, aliis latis vaginatis ad medium. Inflorescentiae geminae, pedunculis ca. 2 cm longis. Spatha albida gracilis 4-5 cm longa, ± cylindrico-convoluta, ad apicem calcarata. Spadix spatha paulo brevior, ad 4 cm longus, 3 mm crassus, parte staminata quam pistillata vix longiore. Ovaria ca. 1 mm lata, 5-locularia, loculis uniovulatis, ovulis prope basim loculi affixis.

Type collection: *G. M. Barroso s.n.* (designated 60R1), cultivated in Jardim Botânico do Rio de Janeiro, April (?) 1960. "Mas não se trata dessa espécie. Segundo Burle Marx, foi colhido no Alto Amazonas. É escandente, delicada, com duas inflorescencias em cada axila foliar." [HOLOTYPUS MO].

Distribution: Amazonian Peru, Brazil.

P. grazielae has been in cultivation in this country and in Brazil for several years. Recently it was discovered in the wild by H. E. Moore in Loreto, Peru, be-

tween Iquitos and Quisto Cocha. No dried specimen was prepared in the field, but the propagule brought back to Cornell University grew and flowered last year. It is the subject of Figure 4, and a dried specimen is preserved in the herbarium of the Bailey Hortorium.

A member of section *Oligospermium* Engler, this species is closely related to *P. frits-wentii*.

The specific name honors Graziela M. Barroso, Chefe de Secção da Botânica Sistemática, Jardim Botânico do Rio de Janeiro, who prepared the type specimen.

Caladiopsis **dodsonii** Bunt., sp. nov. Fig. 5.

Foliorum lamina hastato-tripartita, 27 cm longa, 33.5 cm lata; partitio intermedia elliptica, 22 cm longa, 13 cm lata, ad basim 7 cm lata, ad apicem abrupte acuminata; partitiones laterales ± elliptico-oblongae, inaequilaterae, 16-17 cm longae 7-9 cm latae, acuminatae, lateribus exterioribus rotundatis, costis denudatis ca. 1 cm in sinu. Petiolus 45 cm longus. Pedunculus 40 cm longus. Spatha albo-flavida, 13 cm longa. Spadix paulo brevior, croceus, parte pistillata 5 cm longa, floribus pistillatis 2.5 mm longis, stylis tenuibus cylindricis ovariis aequilongis, ovariis 3-4-locularibus.

Type collection: *C. H. Dodson & L. B. Thien 1190*, collected in Ecuador: Pichincha: Santo Domingo de los Colorados, along Río Baba, 28 km. south of Santo Domingo, elev. 350 m. "Spathe white-pale yellow; spadix brilliant orange; on tree trunk." 3 Nov. 1961 [holotypus MO, unicate].

C. lehmannii Engl., the only other known species of *Caladiopsis*, has much smaller leaf-blades basally sagittate or the basal lobes only slighty turned outward. It was collected west of Popayán, Dept. Cauca, Colombia, between 1500 and 1800 m. alt.

Epipremnum **aureum** (Linden & André) Bunt., comb. nov.

Pothos aureus Linden & André in L'Illustration Horticole 27: 69, pl. 381. 1880.

This widely cultivated species was assigned to the genus *Scindapsus* by Engler (Das Pflanzenreich IV. 23B (Heft 37): 80. 1908), and recently was transferred to *Raphidophora* by Birdsey (Baileya 10: 159. 1962). Flowering material of this species is very similar to that of *Epipremnum pinnatum* (L.) Engl., and must be included in the same genus.

Epipremnum and *Raphidophora* can be separated on the basis of ovary characters, as I have pointed out in Baileya 10: 23, 25. 1962. Ovary differences are a useful generic character throughout the Araceae, and serve to separate other genera of close affinity, such as *Colocasia*, *Alocasia*, and *Xanthosoma*. My studies based on the materials of *Epipremnum* and *Raphidophora* available at New York Botanical Garden and United States National Herbarium clearly demonstrate the existence of two recognizable groups, and they deserve generic recognition.

AN OCCURRENCE OF THE MEDULLOSAN SEED-FERN SUTCLIFFIA IN THE AMERICAN CARBONIFEROUS

TOM L. PHILLIPS AND HENRY N. ANDREWS

ABSTRACT

Two well-preserved petrified stem specimens, with attached petioles are described and referred to *Sutcliffia insignis* Scott; these were obtained from the Carbondale formation, Middle Pennsylvanian, of Illinois and thus extend the known range of the genus beyond Great Britain. The diagnostic features of the genus seem to lie in: the profusely anastomosing nature of the vascular system with one or two central steles being larger than the others; a uniform ring of vascular bundles within the peripheral sclerotic zone (rind) of the petiole; the concentric nature of the vascular bundles in the petioles and especially their enclosing fiber rings. Our specimens are distinguished from the English ones chiefly by the presence of rather massive cortical emergences and they are, accordingly, given the name *S. insignis* var. *tuberculata*. TOM L. PHILLIPS, Department of Botany, University of Illinois, Urbana, Illinois; HENRY N. ANDREWS, Henry Shaw School of Botany, Washington University, St. Louis 30, Missouri.

INTRODUCTION

Previous records of Sutcliffia—Numerous specimens and several species of Medullosa have been reported in recent years from the American Pennsylvanian. These investigations have been summarized and revised in the recent comprehensive study of Delevoryas (1955); it is thus unnecessary to review them in detail here. The allied but distinctive stem genus *Sutcliffia* has been reported previously only on the basis of specimens found in Lancashire, England (Lower Coal Measures); it is the purpose of this account to describe *Sutcliffia* specimens found in Illinois coal-balls of Middle Pennsylvanian age.

Most of what we know about *Sutcliffia* is contained in the original account of Scott (1906) and in a somewhat later study by de Fraine (1912). It may be useful to summarize the salient features of the plant as it is known from their work; the specimens described by both authors were referred to *Sutcliffia insignis* Scott.

The stem described by Scott from the Lower Coal Measures of Shore, Lancashire, measured 12 x 6.5 cm in diameter and the petioles were of about the same size; detached petioles actually exceeded 12 cm in diameter. A massive stele occupied the central part of the stem; this measured about 45 x 16 mm in diameter being slightly crushed and probably was nearly cylindrical and in the vicinity of 25 to 30 mm in diameter in life. It was composed of large tracheids and interspersed parenchyma, and the protoxylems were exarch. This central stele, or stelar segment, was more or less surrounded by smaller steles which departed from the central one and which in turn continued to divide to produce the leaf traces; the latter are described as being concentric in the petioles. Very little secondary xylem was present in Scott's specimen; however, in the one described by de Fraine (probably from the same horizon) it was quite well developed. The prominence of one central stele as described by Scott is, moreover, not as evident in Miss de Fraine's stem. She has prepared restoration drawings of

the cauline vascular system which show it as being composed of one or two large central segments and numerous peripheral ones of variable size; the entire complex forms a system in which the units divide and anastomose profusely, with the smaller vascular divisions departing as leaf traces. It is understandable that some authors insist on regarding this as a single stelar system of numerous meristeles rather than one consisting of several steles. In Scott's specimen the outer cortex is characterized by a rind of numerous non-anastomosing fiber strands which are more or less isodiametric to radially elongate in transverse section; extra-stelar tissues were not preserved in de Fraine's fossil.

The vascular strands in the petiole are concentric, that is, the phloem completely surrounds the xylem, in contrast to the collateral disposition of these tissues in the genus *Medullosa*. Scott places considerable weight on this as a distinctive taxonomic feature, somewhat too much weight we feel in view of the fact that the presumed phloem in medullosan stems and petioles is more often than not incompletely preserved; only very rarely has the diagnostic nature of sieve cells in fossil plants been satisfactorily demonstrated, as, for example, in the secondary phloem of the pteridosperms *Medullosa noei* (Stewart, 1951), *Heterangium americana* (Hall, 1952), and *Callistophyton poroxyloides* (Delevoryas and Morgan, 1954). Certainly the most striking feature (even to the naked eye) in Scott's specimen, and in our two from Illinois, is the presence of a discontinuous ring of fiber strands around individual vascular bundles passing through the cortex of the stem (leaf traces) and those in the petiole.

The distinctive features of *Sutcliffia* seem to lie in:

1. The profusely anastomosing nature of the stelar system with one or two major steles usually evident in transverse section.

2. The trace departures to leaves from the stelar system being proximally comparable to miniature steles with little or no secondary development, and the foliar traces with parenchyma among the tracheids.

3. A distinctive ring of vascular bundles within the peripheral sclerotic zone (rind) of the petiole.

4. The concentric nature of the vascular bundles in the petioles and especially their enclosing fiber rings.

The particular interest in the specimens described below lies in the occurrence of *Sutcliffia* in the American Carboniferous and the discovery of an excellently preserved petiole (fig. 6) which was found attached to the adjoining stem. Our specimens are certainly closely related to the English ones, and in view of the difficulty in ascribing specific differences to medullosan specimens with such variable stelar construction from one level to another, particularly when one of our specimens is incomplete (in transverse view), and the other is severely crushed, it seems most appropriate to attribute the two middle Pennsylvanian specimens to *Sutcliffia insignis*. The only clear-cut distinction is the presence of rather massive cortical emergences in the Illinois specimens, and we have chosen to classify them as a varietal forms, namely *Sutcliffia insignis* Scott var. *tuberculata*. Since our speci-

mens compare quite closely with the original English ones our description is more brief than would otherwise be necessary.

Description:—*Sutcliffia insignis* Scott var. *tuberculata* Phillips and Andrews

The following account is based on two coal-ball specimens, Nos. 1257 and 1269; the peel and slide preparations, as well as the remainder of the specimens, are preserved in the paleobotanical collections of the School of Botany, Washington University. They were collected at the Sahara Coal Company mine, 4 miles northwest of Carrier Mills, Illinois, from the No. 6 (Herrin) Coal (Carbondale formation of the Kewanee Group) and are of the middle Pennsylvanian age. The specimens are unquestionably referable to the same taxonomic entity and quite possibly may have come from one and the same plant; the preservation is generally very good.

No. 1257 includes a stem that was exposed on one side of a coal-ball (text fig. 1 A). Judging from a comparison with the other specimen (text fig. 1 B) most of the stelar system is present. A portion of several of the steles is cut away and the exposed surface tapered in such a way that more of the stelar system was lost within about one cm; the particular value of the specimen lies in the relatively uncrushed, excellent preservation of that portion of the stem that is present.

No. 1269 is a stem fragment about 20 cm long. It is rather severely crushed and in the initial saw cut the stem was sectioned longitudinally. It contributes useful information concerning the general organization of the stelar system as well as the structure of the secondary wood which is somewhat more strongly developed than in the steles of No. 1257.

It is convenient to begin with No. 1257 in view of the uncrushed steles and and other features that are particularly well preserved. The maximum dimension of that portion of the stem that is preserved (fig. 1) is about 7 cm. Parts of four steles are evident, the largest of which has a maximum diameter in transverse section of about 16 mm; the relative size of the others may be gained from an observation of fig. 5. The steles consist for the most part of primary xylem, there being a maximum development of about 2 mm of secondary xylem. The tracheids and parenchyma of the primary xylem form a rather uniform tissue system (figs. 4, 5. 11); the parenchyma is abundant and the tracheids are large. It is not possible to cite a significant average dimension; however, many of them are more or less circular in cross section and of about 150 μ with some ranging up to 190 μ. Many of the larger tracheids are elongate in cross section attaining maximum dimensions of 180 x 360 μ. For the most part they occur singly or in groups of 2 to 5. A longitudinal section (fig. 17) reveals the primary tracheids as greatly elongate cells with walls composed of multiseriate bordered pits. The associated parenchyma cells are essentially isodiametric with some being slightly elongate horizontally and others vertically elongate.

The secondary xylem is a little more strongly developed in No. 1269, reaching a thickness of 3.5 mm in some of the steles. The tracheids are much smaller than those of the primary wood, ranging from about 54 to 90 μ in their tangential

dimension, with an average of about 72 μ. The radial walls are composed of multiseriate bordered pits (fig. 7) and appear much like those of the primary tracheids. Bordered pits are present in the tangential walls of the secondary tracheids but they are sparsely distributed over the wall quite in contrast to the densely crowded condition of the radial walls. The interspersed wood rays are abundant and often several cells broad (figs. 11, 16). The longitudinal dimension of the wood rays is great, being at least 1 cm and possibly much taller; they seem to have essentially parallel sides as viewed in a tangential section. As seen in radial section the ray cells vary somewhat in shape; a representative portion is illustrated in fig. 15.

The dominance of the central stele is more pronounced in No. 1269. The entire stem is rather strongly crushed; peel 1269B-10 seems to be representative and in spite of the crushing it is evident that one stele was considerably larger than the others (text fig. 1). It is not possible to give exact measurements due to the crushing and the fact that the large stele is broken, but it seems safe to estimate that it had a diameter well in excess of 2 cm in life. This stem also includes three other conspicuous steles although they are distinctly inferior in size to the central one; they were certainly under one cm in diameter before fossilization. There are several smaller stelar units which have resulted from divisions of the four main ones; it is evident from the peel preparations that these smaller units of the stelar system undergo frequent divisions in giving off segments that ultimately become petiolar traces.

The characteristic medullosan internal periderm is present; where it is well preserved it appears, a few mm outside the stelar system, as a narrow, uniform band about 5-6 cells thick (radially). Due to crushing and distortion it is incomplete in all of our preparations and deserves more detailed study.

In dealing with the extrastelar tissues is seems most convenient to start from the outside. The outermost cortex, which may be rather clearly delimited as the *rind*, is 5 to 7 mm thick and consists of a groundwork of parenchyma with abundant fiber strands that vary from circular to radially elongate in transverse section. There is a uniform row of vascular bundles distributed through them (figs. 6, 19).

The fiber strands present several points of interest that apparently were not observed in the English specimens. A tangential section (fig. 8) reveals them as being essentially parallel, there being only an occasional tendency to anastomose. In particularly well preserved radial sections we have observed a distinctive jointing of the fiber strands; the cells have conspicuous transverse walls uniformly across the width of the strand. The length of the "joints," or rather of the component cells ranges from about 0.5 to 1.5 mm. This jointed effect does not appear in all of our preparations and we are not entirely certain whether this is due to differences in the quality of preservation or whether it is a variable character.

Although not a highly conspicuous feature of the rind there are fairly abundant secretory cells present. It may be admitted that they are referred to as "secretory cells" for want of more appropriate terminology; they are slightly larger than most of the surrounding parenchymatous cells (figs. 12, 13) and contain remnants of a

Text figure 1. Cross sectional diagrams of the two stem specimens. Solid black = primary wood; lined areas = secondary wood; dotted lines indicate approximate inner limit of rind. A, peel 1257-Bt-11; B, peel 1269-B-10. Both about 1.5x.

substance that is coal-black. These cells may be located at the peripheral part of a fiber bundle or at some point within it.

Within the rind the cortex consists of a parenchymatous ground tissue with irregularly distributed vascular bundles. The most conspicuous feature of *S. insignis*, when transverse sections are observed under a low power lens or with the unaided eye, is the ring of fiber strands that surrounds each bundle; these are mentioned in further detail below.

Specimen No. 1257 also included a petiole base (fig. 6) in an excellent state of preservation; this was found to be in organic connection with the stem shown in figure 1. The petiole measures about 4 cm in diameter; as shown in figure 6 it is oriented slightly oblique to a perfect transverse section and there is a conspicuous appendage at one side the nature of which has not been determined. The rind is sharply defined and measures about 3 to 4 mm thick; also distinctive are the vascular bundles which are distributed in a regular row within it.

Internal to the rind the vascular bundles are enclosed, very conspicuously (fig. 18), within a fibrous ring. A single vascular strand is enclosed by a fiber ring except where the strand is dividing (fig. 20). The fiber ring itself may consist of a nearly complete fibrous band, or of several tangentially elongate ones, but more frequently of a dozen essentially cylindric strands. These highly distinct units (fiber ring and enclosed vascular strand) range from about 2 to 3 mm in diameter.

Finally, we may consider the only feature that seems to clearly separate these Illinois specimens from the previously described English ones, namely the rather massive emergences on the stems and petiole bases (figs. 2, 3). They are nearly hemispherical mounds of parenchyma about 1 to 1.5 mm in maximum diameter. They appear essentially the same in transverse and longitudinal section, seem to be complete as preserved, and there is no evidence that there was any vascular tissue penetrating them. During the course of our investigation coal-ball No. 1269 split between the specimen and the enclosing matrix revealing two or three square inches of the stem surface (fig. 14). It was not possible to obtain a very satisfactory photograph but some concept may be gained of the surface with its irregularly scattered emergences.

It may be useful to summarize our description of the plant on the basis of the Illinois specimens:

Sutcliffia insignis Scott var. *tuberculata* Phillips and Andrews. Our study is based on two fragmentary specimens which indicate a stem with a diameter of about 7 cm. The stelar system includes one or two units that are larger than the others, attaining a diameter of 16 mm with a maximum of about 3.5 mm of secondary xylem. The general organization of the stelar system conforms with that of the English specimens. The leaf traces in the petiole are distributed as a distinctive ring in the rind and those within the rind are enclosed in a ring of fiber strands. Apparent secretory cells, only slightly larger than those of the other parenchyma, are associated with the fiber strands in the rind. Conspicuous mound-shaped emergences about 1 to 1.5 mm in diameter are present on the stem and petiole bases.

Location: Sahara Coal Company mine, 4 miles northwest of Carrier Mills, Illinois.

Horizon: No. 6 (Herrin) Coal, Carbondale formation, Middle Pennsylvanian.

Discussion:

The particular interest in the Illinois specimens of *Sutcliffia* seems to lie in the extended range of this interesting plant and in a few additions to our knowledge of its structure and variability in certain features. We were inclined at first to regard our specimens as belonging to a distinct species; in this tentative decision we were perhaps most strongly influenced by the greater dominance of the central stelar unit as shown in Scott's original specimen. This is understandable if his Plate 7, figs. 1-5 (Scott, 1906) be compared with our fig. 1 and text fig. 1. However, having available the additional evidence afforded by Miss de Fraine's specimens and the known variation in medullosan stelar anatomy in general, the literature of which is summarized by Delevoryas (1955), the case for a new species is not as convincing. It may not be entirely amiss, however, to note the relatively poor preservation of the primary xylem and the abundance of secondary xylem in the de Fraine specimens in contrast to the corresponding features of those described by Scott; the comparison is further clouded by the lack of preservation of extrastelar tissues in the de Fraine specimens. Quite clearly we need to know more about the specimen-to-specimen variation in *Sutcliffia* and particularly its ontogeny.

Judging from what has been learned in recent years about the variation in the stelar anatomy in species of *Medullosa*, or rather the difficulty in delimiting species in that genus, it is quite possible that Scott's specimens and those described above could reasonably fall within the limits of a single species.

The Illinois collection does include especially well preserved petioles which add appreciably to our knowledge of the plant. The particularly fine specimen shown in fig. 6 was shown to be attached to the stem illustrated in fig. 1 and reveals very clearly the distinctive distribution of the vascular bundles in the rind and the fiber-ringed aspect of the bundles which lie within the rind.

As noted above the massive emergences described for the Illinois specimens constitute the feature that has led us to designate a separate variety. They are certainly distinctive structures and were not reported by Scott. It should be noted, however, that our cortical tissues and petiole bases seem to be better preserved than in the English specimens, and the distribution of the emergences is somewhat erratic; they are not present in many peel preparations and appear to have been absent from some parts of the stem.

A few comments concerning the phylogenetic position of *Sutcliffia* may be in order. First, a comparison of the genus with *Medullosa* suggests the following differences. The stelar system of *Sutcliffia* is dominated by one, or occasionally two, central steles which are more or less ringed by distinctly smaller ones. It does not display the marked asymmetric secondary wood development that is frequently observed in *Medullosa*. The leaf trace system in *Sutcliffia* bears a

greater resemblance to a branch system than in *Medullosa*. And particularly noteworthy is the difference in petiole structure, with the peripheral ring of bundles in the rind and the internal bundles which are less numerous than in medullosan petioles and enclosed by a fiber ring.

In recent discussions of racial trends in the Medullosaceae *Sutcliffia* has been placed in an ancestral position (Stewart and Delevoryas, 1952; Delevoryas, 1955) and several previous authors regarded it as primitive within the family; an exception to this is the scheme offered by Baxter (1949) in which it is considered to be derived from *Medullosa*. While the discovery of *Sutcliffia* originally suggested evolutionary considerations within the medullosan complex, the phyletic position of this allied genus, which simulates a group of *Heterangium* steles cloaked in a medullosan mantle, remains a matter of speculation. Whether the stelar system of *Sutcliffia* is regarded as polystelic or monostelic with a central segment flanked by smaller meristeles seems to largely reflect phylogenetic inferences of syngenesis or of division and branching of the stelar system.

The stratigraphical position of *Sutcliffia* does not offer significant help in solving the problem. In a recent study of the Pennsylvanian strata of Illinois (Kosanke et al. 1960) the Herrin coal is shown in about the middle of the Carbondale formation. Referring to the correlation chart given by Schopf (1941), medullosan stems are known from this country both above and below the Herrin coal and the English *Sutcliffia* specimens come from a somewhat lower horizon, the Lower Coal Measures, which also includes *Medullosa anglica*.

It is interesting to note that regardless of the position of *Sutcliffia* in the phyletic schemes of Baxter and of Delevoryas, fusion of steles has been suggested by both authors. As the plant is known to us the stelar system consists of several distinct units, and it seems both appropriate and convenient to use the term polystelic. The mixed protosteles, and concentric foliar traces with parenchyma interspersed among the tracheids, grade out from the large central stele to small leaf traces and even to bundles of the petiole; Scott regarded the lateral steles (meristeles) of *Sutcliffia* as transitional between leaf traces and steles. Indeed, the transition seems much more evident in size and number in the Lancashire specimens than in the two from Illinois. While the most significant differences (consistent with age differences) between English and American specimens may lie in the relative sizes and numbers of steles (i.e., increased distinction between lateral steles and leaf traces), we have an insufficient knowledge of the specimen-to-specimen variation to justify further elaboration of this key point. It also seems clear that further phylogenetic speculations can contribute little until additional information is acquired.

Acknowledgement

This study was aided in large part by grants made to one of us (HNA) from the National Science Foundation and the John Simon Guggenheim Memorial Foundation.

Literature Cited

Baxter, R. W. 1949. Some pteridosperm stems and fructifications with particular reference to the Medullosae. Ann. Missouri Bot. Gard. 36: 287-353.

de Fraine, E. 1912. On the structure and affinities of *Sutcliffia,* in the light of a newly discovered specimen. Ann. Bot. 26: 1031-1066; pl. 91, 92.

Delevoryas, T. 1955. The Medullosae—structure and relationships. Palaeontographica 97B: 113-167.

Delevoryas, T., and J. Morgan. 1954. A new pteridosperm from Upper Pennsylvania deposits of North America. Palaeontographica 96B: 12-23.

Hall, J. W. 1952. The phloem of *Heterangium americanum.* Amer. Mdl. Nat. 47: 763-768.

Kosanke, R. M., et al., 1960. Classification of the Pennsylvanian strata of Illinois. Illinois State Geol. Survey, Rept. Invest. No. 214, pp. 1-84.

Schopf, J. M. 1941. Contributions to Pennsylvanian paleobotany, *Mazocarpon oedipternum,* sp. nov. and Sigillarian relationships. Illinois State Geol. Survey, Rept. Invest. No. 75, pp. 1-40.

Scott, D. H. 1906. On *Sutcliffia insignis,* a new type of Medulloseae from the Lower Coal-Measures. Trans. Linn. Soc. London, Ser. 2. Botany. 7: 45-68; pl. 7-10.

Stewart, W. N. 1951. *Medullosa pandurata* sp. nov. from the McLeansboro group of Illinois. Amer. Journ. Bot. 38: 709-717.

——— and T. Delevoryas. 1952. Bases for determining relationships among the Medullosaceae. Amer. Journ. Bot. 39: 505-516.

Explanation of Plate

Plate I

Sutcliffia insignis var. *tuberculata*

Fig. 1. Transverse view of specimen No. 1257; the larger central stele appears at *A*. Peel 1257-B-21, about 2.3 x.

Fig. 2. An emergence in longitudinal section. Slide 3131, 23 x.

Fig. 3. An emergence in transverse section. Slide 3128, 23 x.

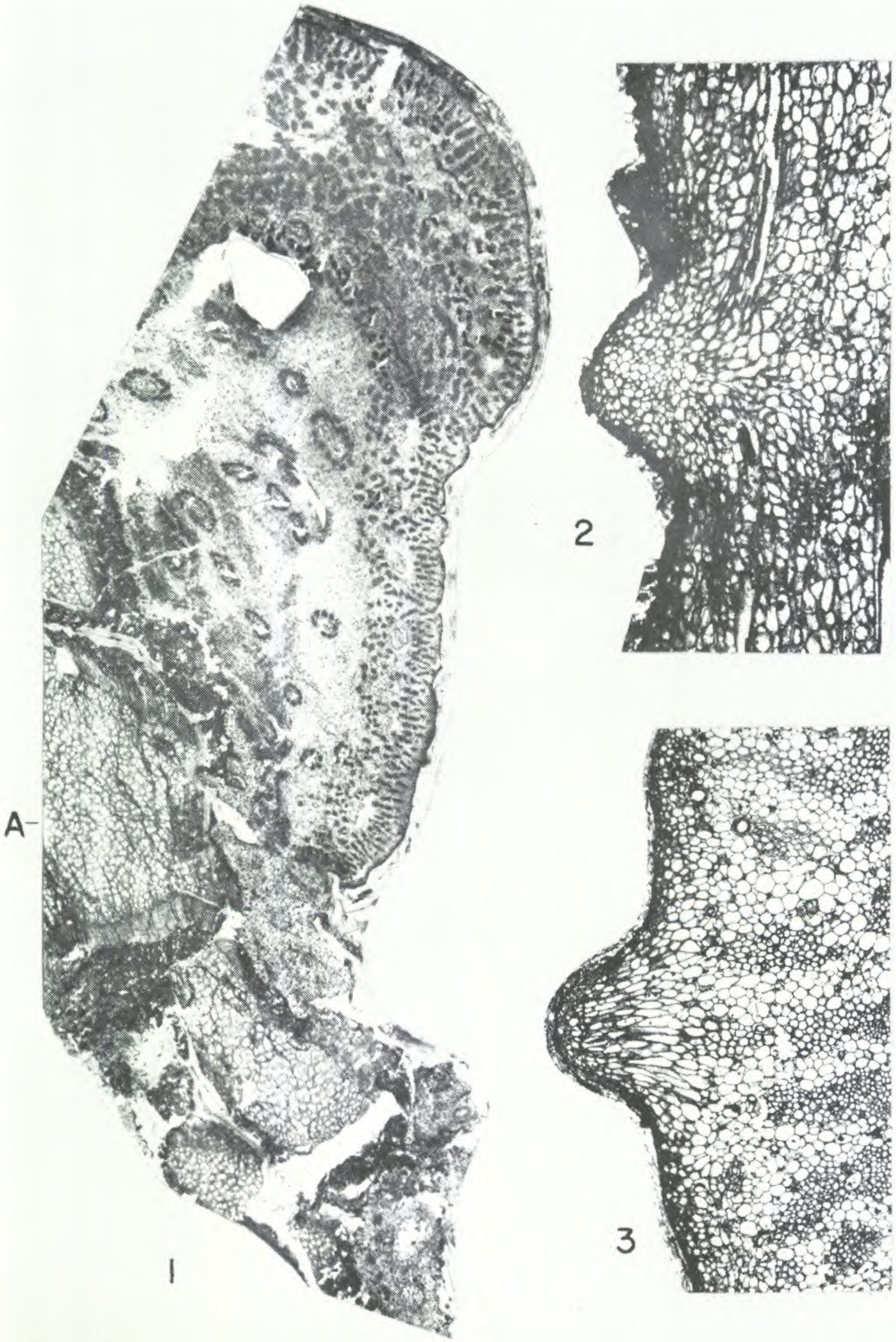


Plate I

Explanation of Plate

Plate II

Sutcliffia insignis var. *tuberculata*

Two views of the stelar system of No. 1257; the stele *S* has divided into two in figure 5.

Fig. 4. Peel 1257-Bt-1, 5 x.

Fig. 5. Peel 1257-Bt-21, 4.5 x.

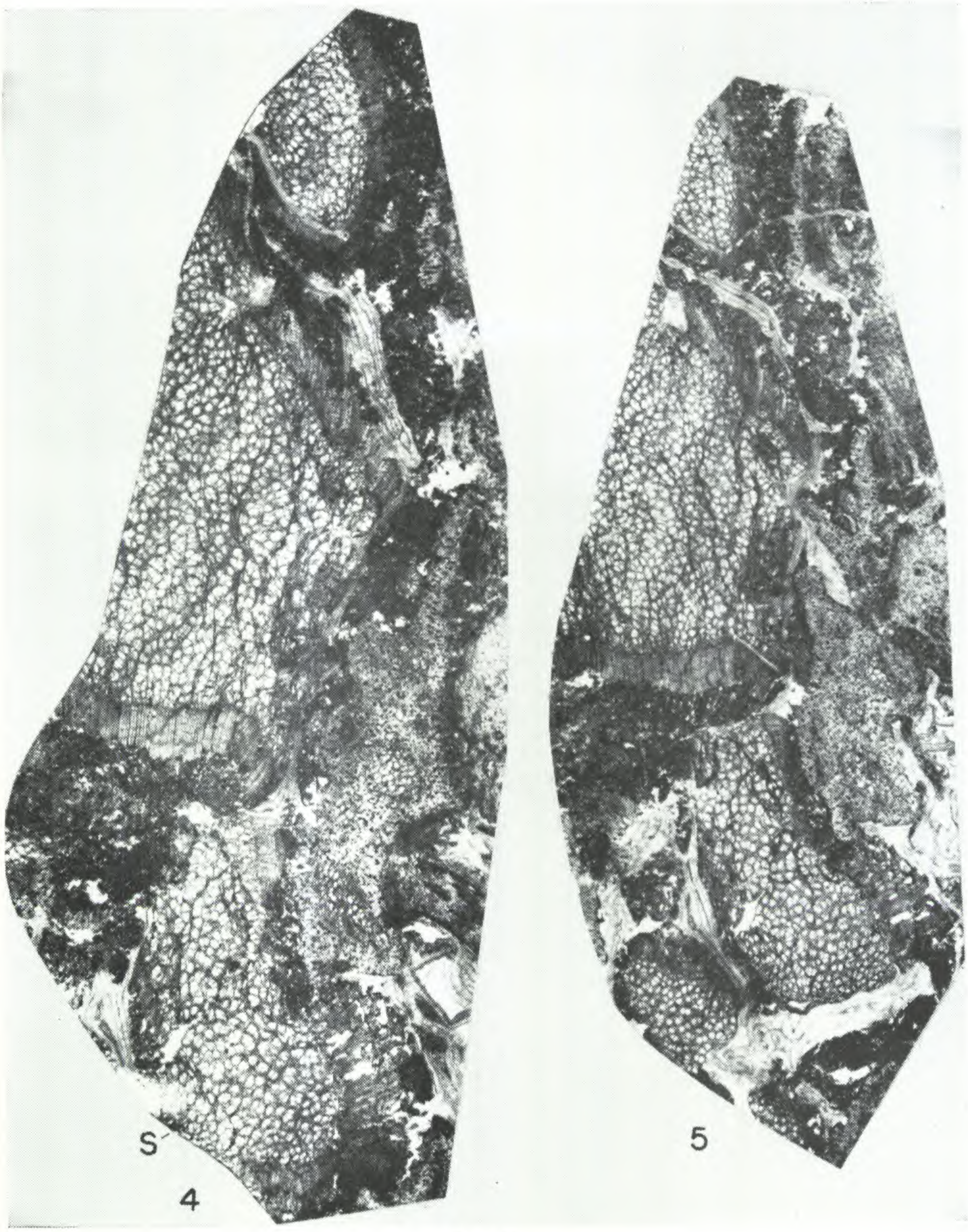


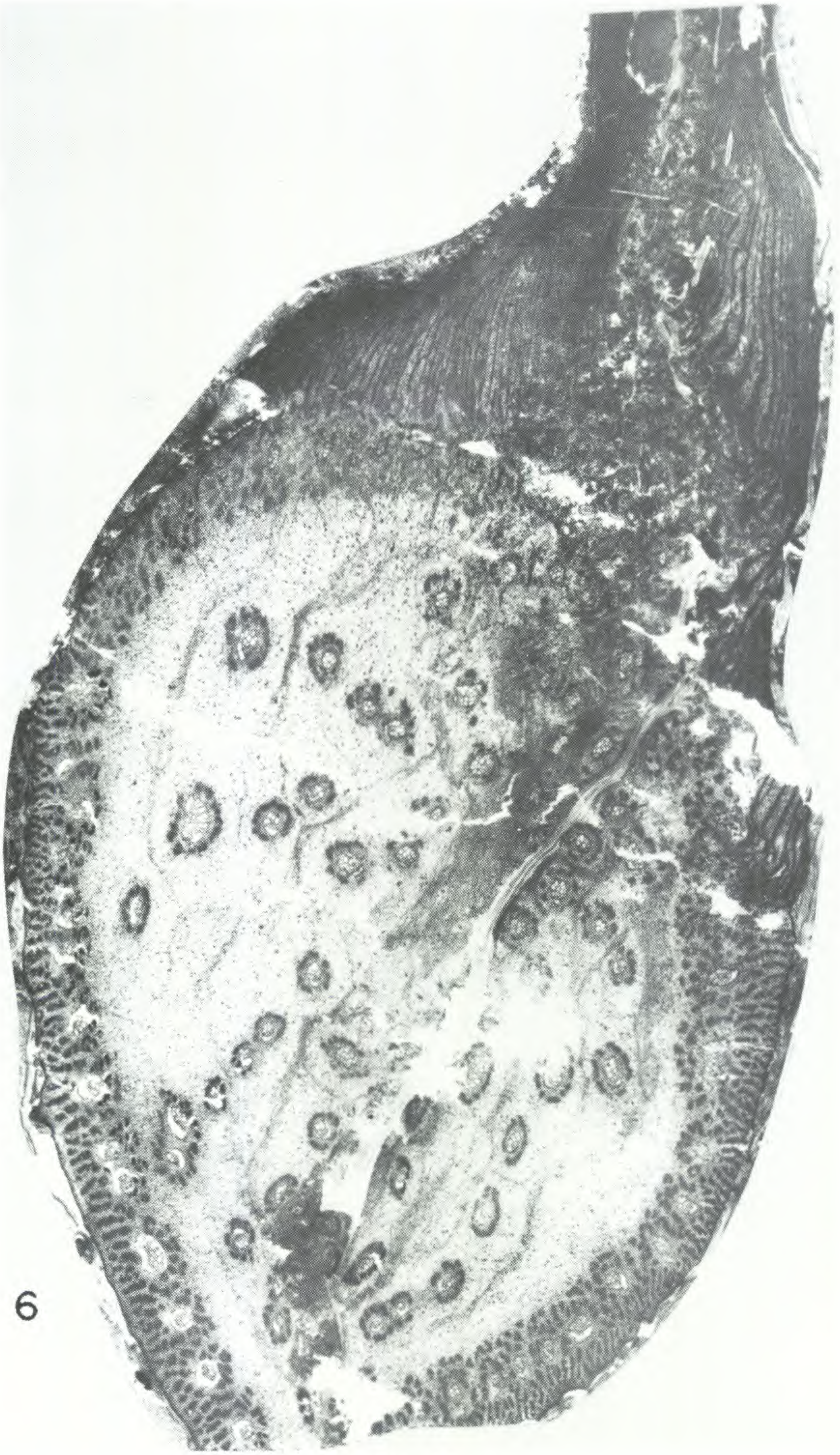
Plate II

Explanation of Plate

Plate III

Sutcliffia insignis var. *tuberculata*

Fig. 6. Tranverse view of petiole attached to stem of No. 1257. Peel 1257-Cs-33, 3 x.



6

Plate III

Explanation of Plate

Plate IV

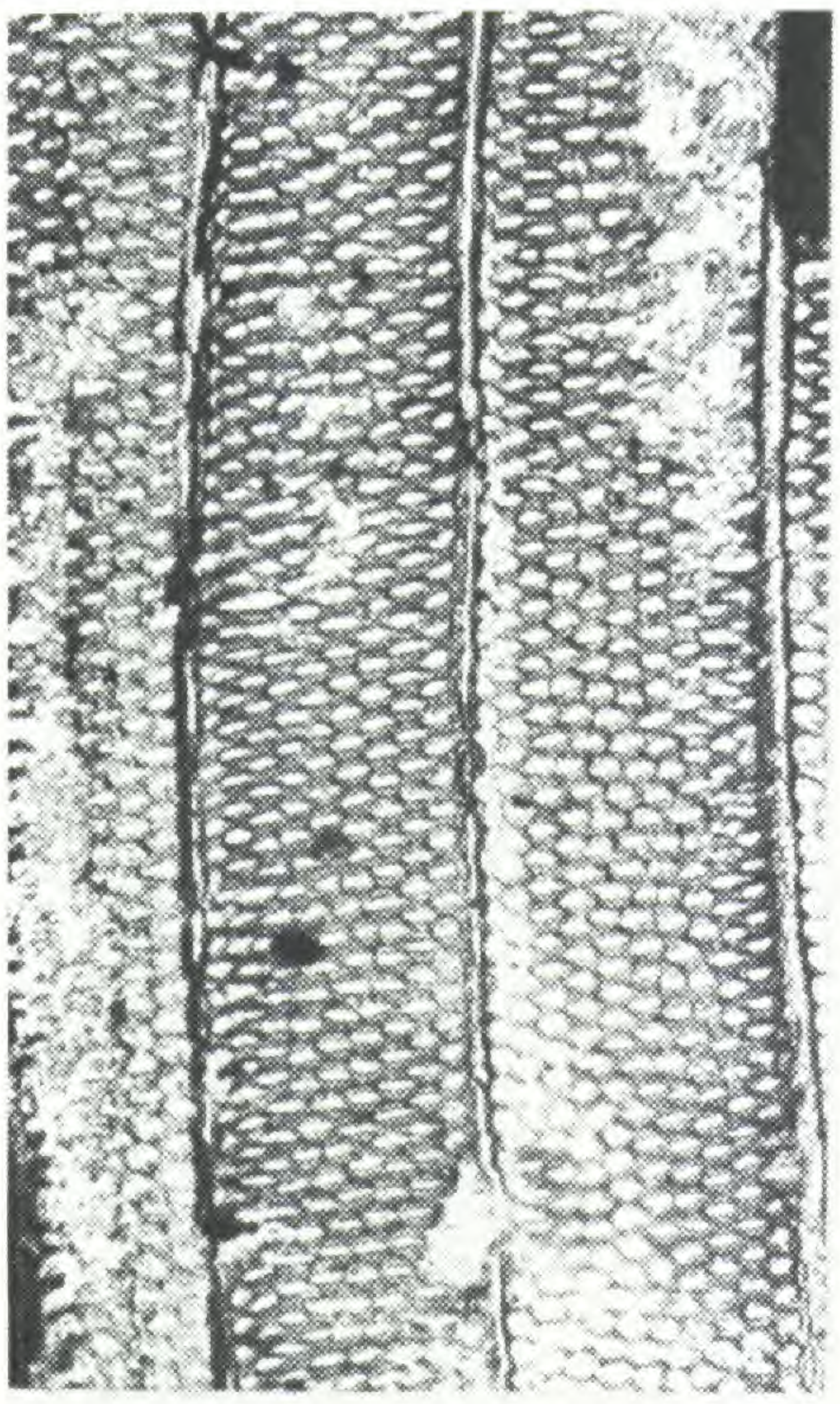
Sutcliffia insignis var. *tuberculata*

Fig. 7. Pitting in radial walls of secondary tracheids. Slide 3132, 128 x.

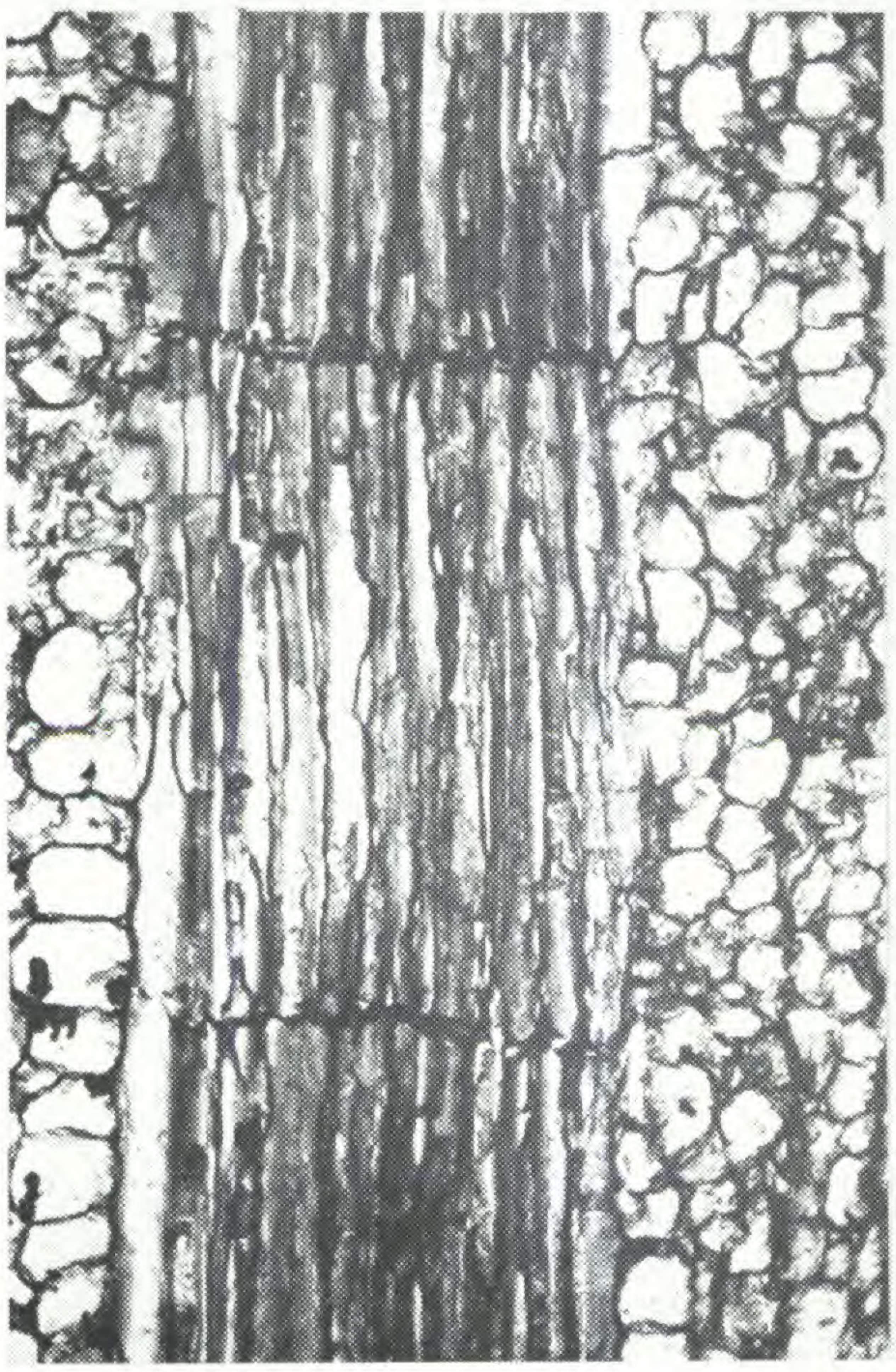
Fig. 8. Tangential longitudinal view through rind showing fiber strands. Slide 3131, 24 x.

Fig. 9. A single fiber strand from Fig. 10. Slide 3136, 62 x.

Fig. 10. Fiber strands of rind in radial longitudinal view showing jointing. Slide 3136, 15 x.


7

8


9

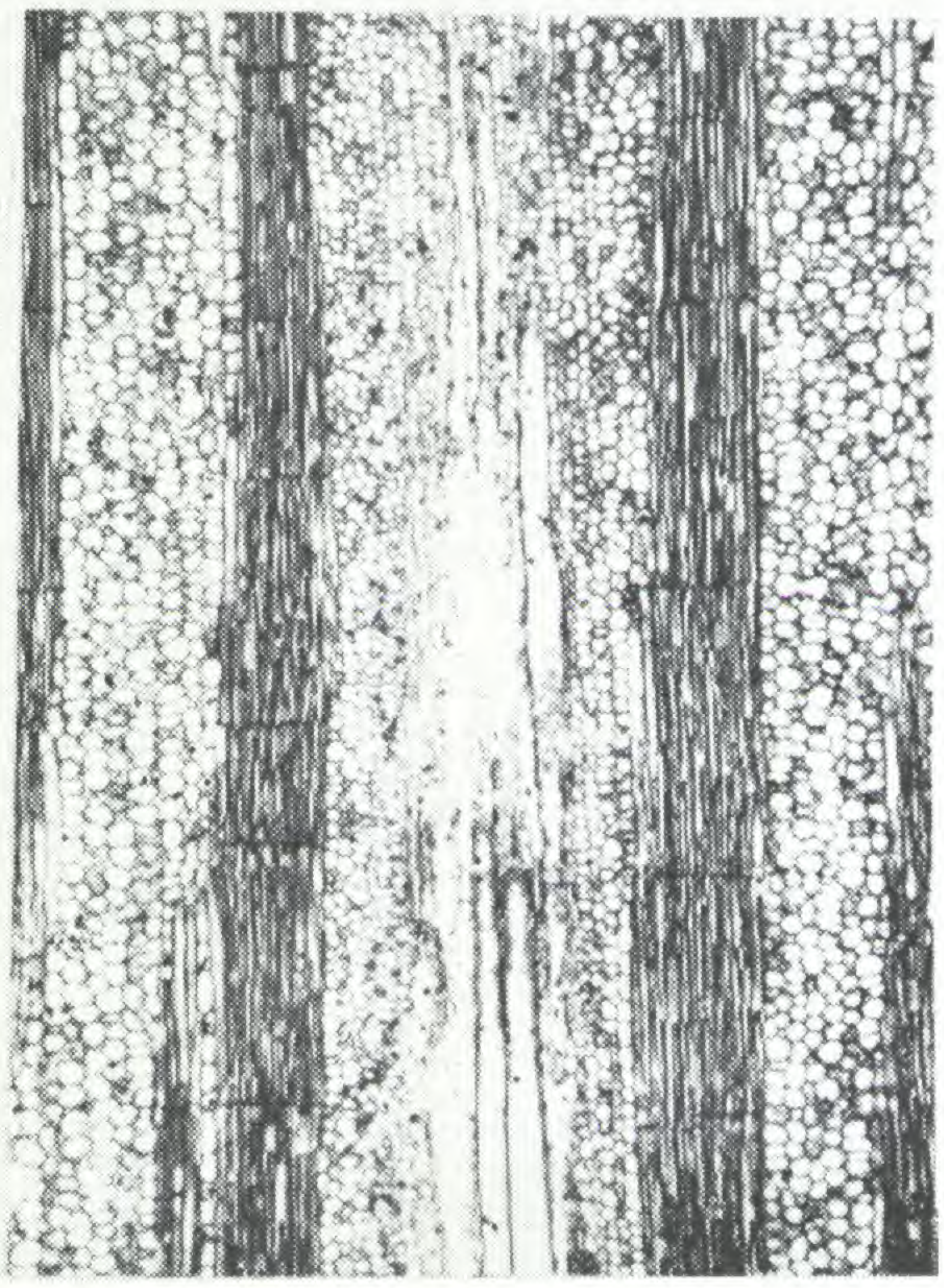
10


Plate IV

EXPLANATION OF PLATE

Plate V

Sutcliffia insignis var. *tuberculata*

Fig. 11. Transverse view of outer portion of a stele showing primary wood (X1), secondary wood (X2) and phloem (P). Slide 3127, 38 x.

Figs. 12, 13. The rind in transverse view showing apparent secretory cells. Slide 3124, 67 x.

Fig. 14. A portion of the external surface of the stem showing emergences. About 5 x.

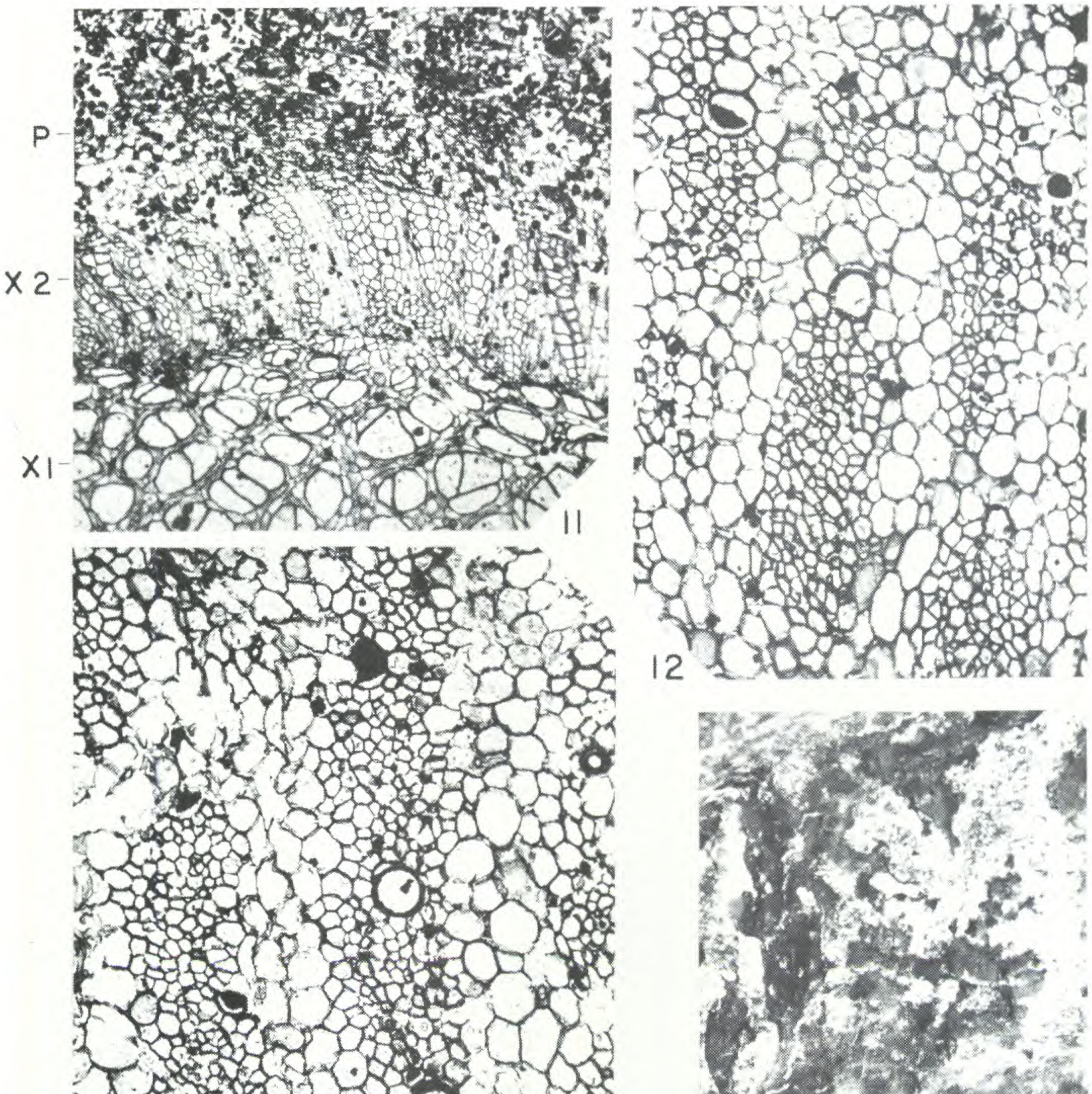


Plate V

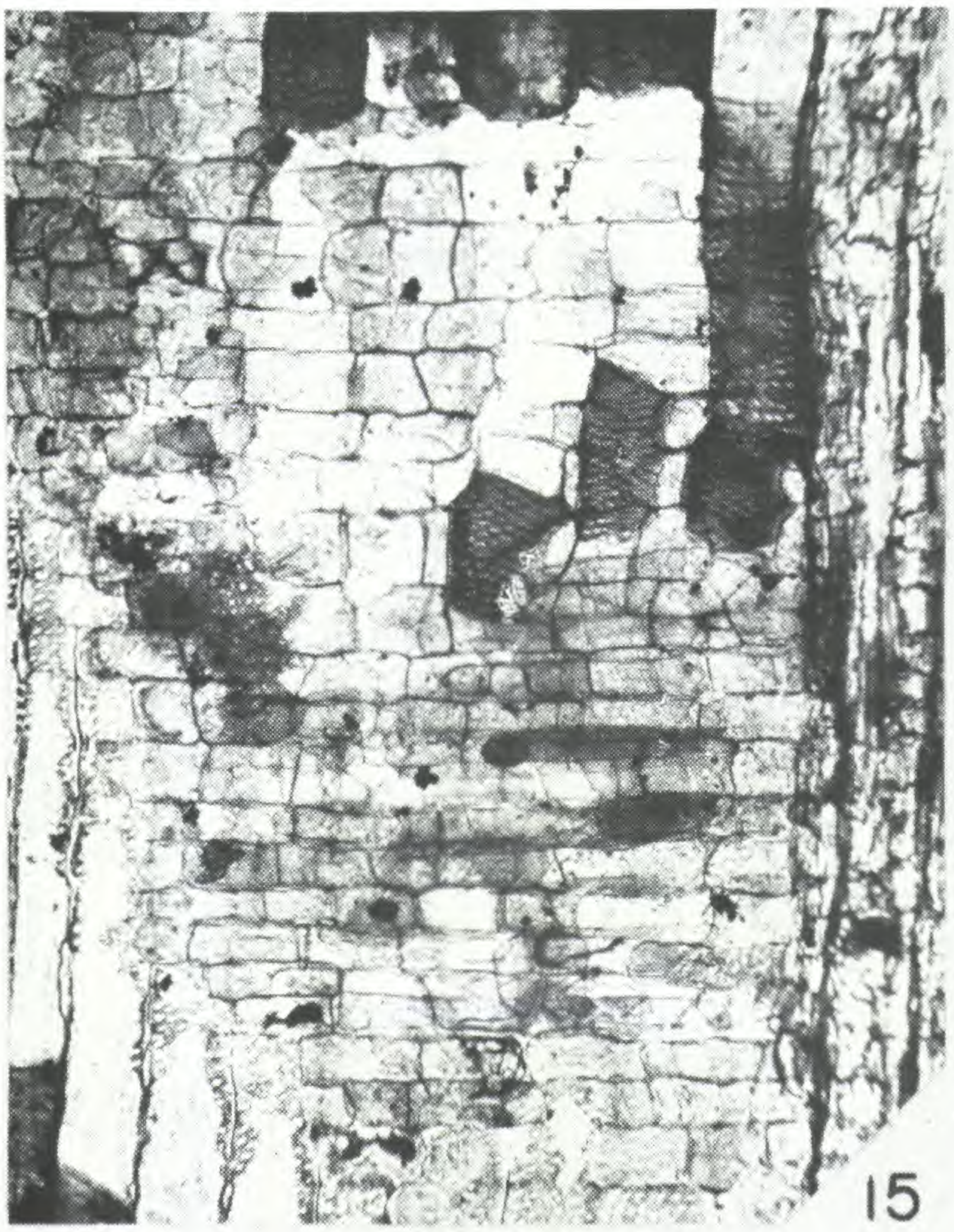
EXPLANATION OF PLATE

Plate VI

Sutcliffia insignis var. *tuberculata*

Fig. 15. Radial view of a ray in the secondary wood. Slide 3134, 70 x.

Fig. 16. Tangential view of secondary wood. Slide 3123, 80 x.



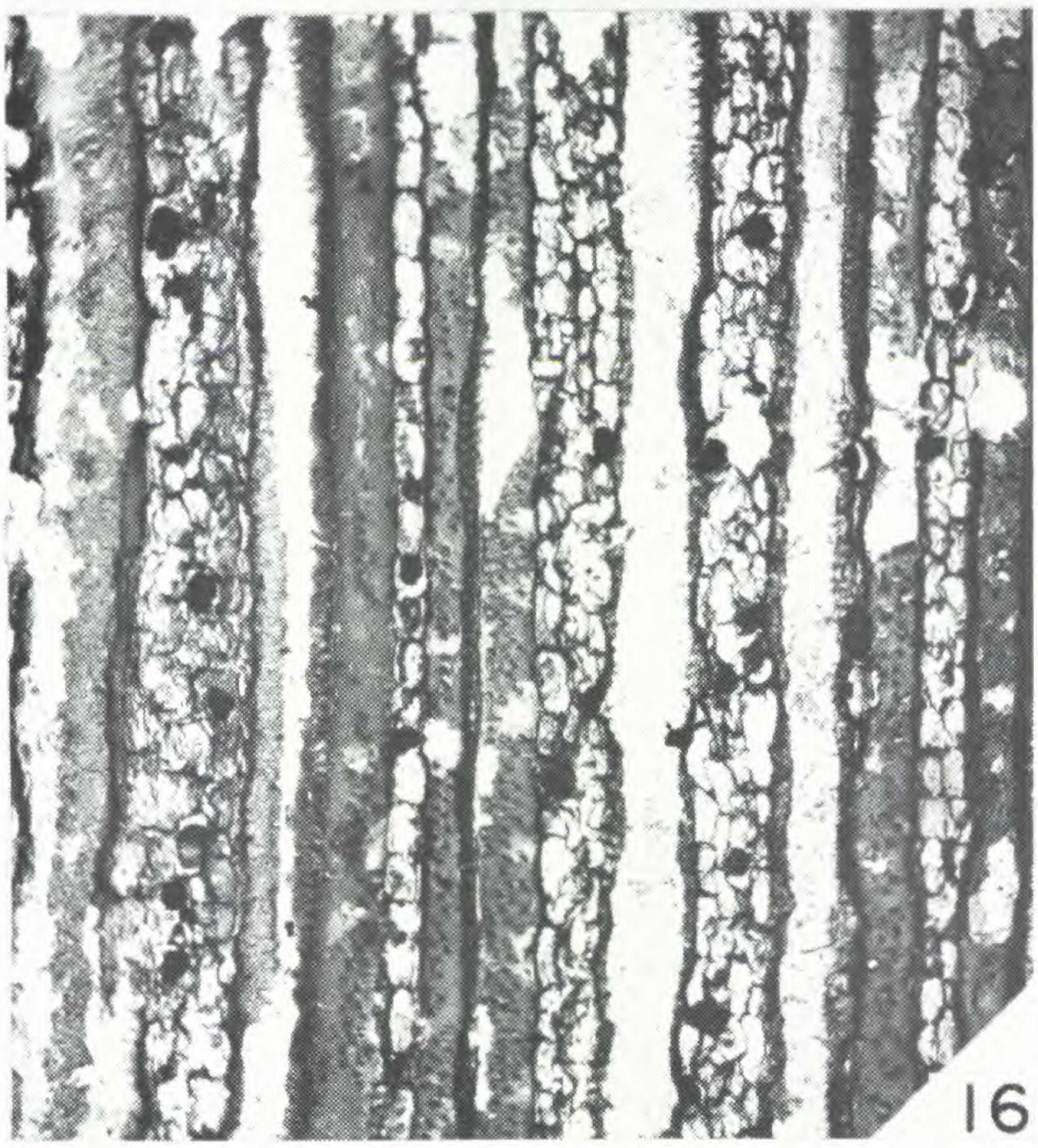


Plate VI

Explanation of Plate

Plate VII

Sutcliffia insignis var. *tuberculata*

Fig. 17. A longitudinal view of the primary wood. Slide 3130, 53 x.

Fig. 18. A vascular bundle in the cortex, with enclosing ring of fiber strands. Slide 3124, 34 x.

Fig. 19. A vascular bundle in the rind; the narrow black band in the top center of the photograph represents the periphery of the stem. Slide 3124, 34 x.

Fig. 20. A pair of vascular bundles in the cortex with enclosing ring of fiber strands. Slide 3121, 27 x.

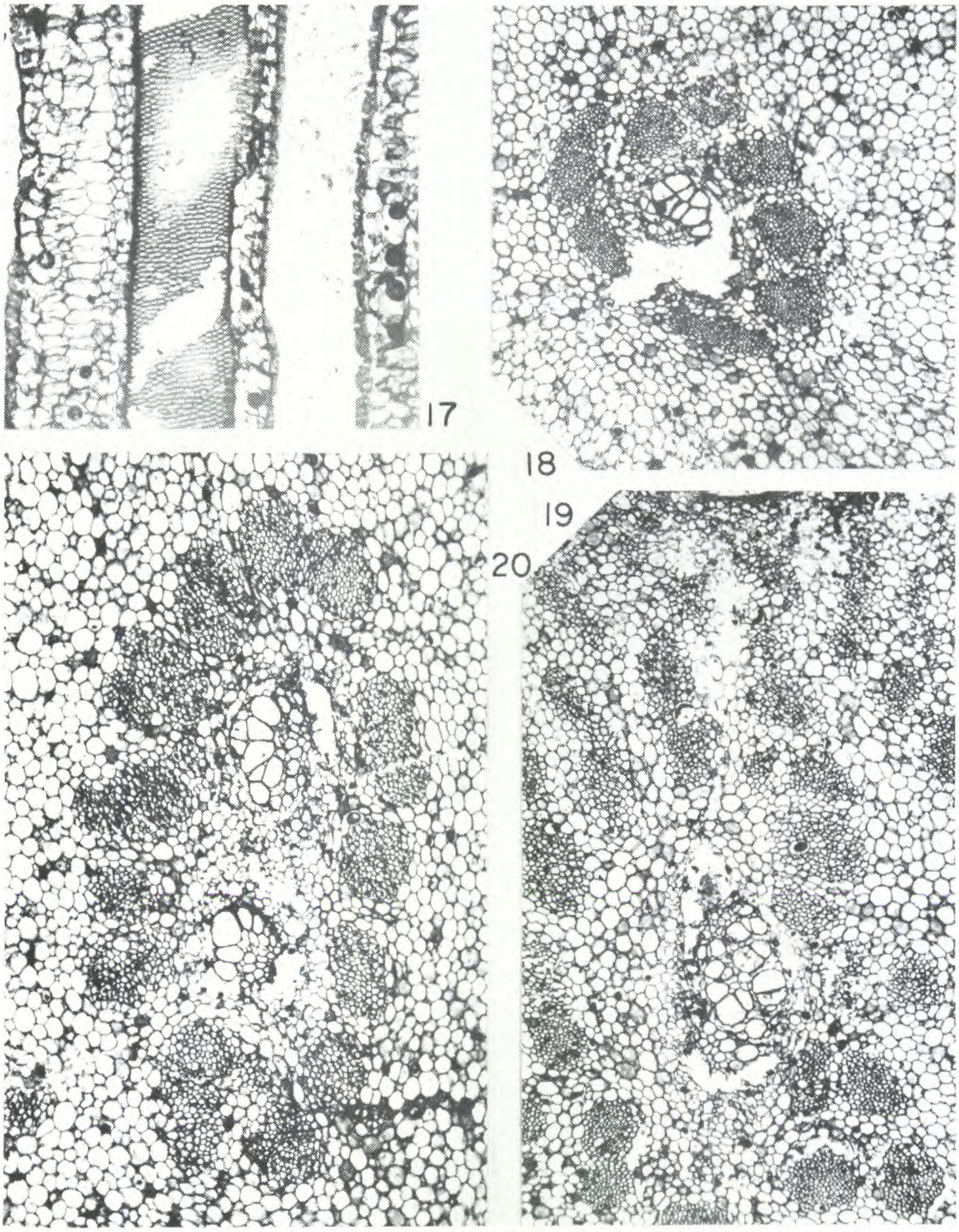


Plate VII

INDEX OF ORCHID NAMES — 1962

ROBERT L. DRESSLER

Names which were omitted from the 1961 index (Annals 49: 131-136. 1962) are indicated by asterisks.

Angraecum **brevicornu** Summerh., Kew Bull. 16: 311. Tanganyika (K).
Brachionidium **cruzae** L. O. Wms. Brittonia 14: 441. Costa Rica (F).
Brachycorythis **tanganyikensis** Summerh., Kew Bull. 16: 257. Tanganyika (K).
Brassavola digbyana var. **fimbripetala** (Ames) H. G. Jones, Orchid Rev. 70: 234. *Laelia digbyana* var. *fimbripetala* Ames.
Bulbophyllum **mackeeanum** Guillaumin, Bull. Mus. Hist. Nat. Par. II 34: 95. Burma (P?).
Bulbophyllum **nigericum** Summerh., Kew Bull. 16: 307. Northern Nigeria (K).
Bulbophyllum **wrightii** Summerh., Kew Bull. 16: 309. Eastern Camaroons (K).
Cranichis **crumenifera** Garay, Caldasia 8: 518. Colombia (COL).
Cyrtidium **alatum** (Lindley) Garay, Caldasia 8: 525. *Camaridium alatum* Lindley.
Cyrtopodium **paniculatum** (Ruiz & Pavón) Garay, Caldasia 8: 524. *Maxillaria paniculata* Ruiz & Pavón.
Diaphananthe **ovalis** Summerh., Kew Bull. 16: 313. Congo Republic (K).
Epidendrum **glandulosum** (HBK.) Garay, Caldasia 8: 523. *Cymbidium glandulosum* HBK., preoccupied by *Epidendrum glandulosum* Ames, 1924.
Epidendrum **leucanthum** (Schltr.) C. Schweinf., Bot. Mus. Leafl. 20: 17. *Encyclia leucantha* Schltr.
Epidendrum rectopedunculatum forma **denticulatum** C. Schweinf., Bot. Mus. Leafl. 20: 18. Venezuela (AMES).
Epidendrum **remotiflorum** C. Schweinf., Bot. Mus. Leafl. 20: 18. Venezuela (AMES).
Erythrodes **robusta** C. Schweinf., Bot. Mus. Leafl. 20: 8. Venezuela (AMES).
Chondrorhyncha **flabelliformis** (Sw.) Alain, Phytologia 8: 369, *Epidendrum flabelliformis* Sw.
Cycnoches pentadactylon var. **cooperi** (Rolfe) Pabst, Orquidea (Bras.) 24: 46. *Cycnoches cooperi* Rolfe.
Cynorkis buchwaldiana subsp. **braunii** (Kränzlin) Summerh., Kew Bull. 16: 258. *Cynorkis braunii* Kränzlin.
Cynorkis buchwaldiana subsp. **nyassana** (Schltr.) Summerh., Kew Bull. 16: 258. *Cynorkis nyassana* Schltr.
Dendrobium **pseudo-intricatum** Guillaumin, Bull. Mus. Hist. Nat. Paris II 34: 262. Annam (P?).
Habenaria section **mirandae** Summerh., Kew Bull. 16: 301. Type species: *H. rautaneniana* Kränzlin.
Habenaria **apiculata** Summerh., Kew Bull. 16: 261. Tanganyika (K).
Habenaria **burttii** Summerh., Kew Bull. 16: 275. Tanganyika (K).
Habenaria **calvilabris** Summerh., Kew Bull. 16: 303. Urundi, Northern Rhodesia, Southern Rhodesia (K).
Habenaria **compta** Summerh., Kew Bull. 16: 276. Angola, Northern Rhodesia (K).
Habenaria **disparilis** Summerh., Kew Bull. 16: 277. Congo Republic, Nyasaland, Northern Rhodesia, Southern Rhodesia (K).
Habenaria **haareri** Summerh., Kew Bull. 16: 281. Tanganyika (K).
Habenaria **insolita** Summerh., Kew Bull. 16: 259. Tanganyika (K).
Habenaria **macrotidion** Summerh., Kew Bull. 16: 285. Northern Rhodesia (K).
Habenaria **modica** Summerh., Kew Bull. 16: 263. Nyasaland, Northern Rhodesia, Southern Rhodesia (K).
Habenaria myodes subsp. **latipetala** Summerh., Kew Bull. 16: 289. Ruanda, Uganda (K).
Habenaria **myodes** Summerh. subsp. *myodes*, Kew Bull. 16: 287. Tanganyika, Nyasaland, Southern Rhodesia (SRGH).
Habenaria nyikana subsp. **pubipetala** Summerh., Kew Bull. 16: 291. Tanganyika (K).
Habenaria **parvifolia** Summerh., Kew Bull. 16: 265. Tanganyika, Northern Rhodesia (K).
Habenaria **retinervis** Summerh., Kew Bull. 16: 291. Congo Republic, Tanganyika, Northern Rhodesia (K).
Habenaria **stenophylla** Summerh., Kew Bull. 16: 293. Tanganyika (K).
Habenaria **strangulans** Summerh., Kew Bull. 16: 295. Southern Rhodesia (SRGH).
Habenaria **subaequalis** Summerh., Kew Bull. 16: 297. Southern Rhodesia (SRGH).

Habenaria **tetraceras** Summerh., Kew Bull. 16: 267. Congo Republic, Tanganyika, Northern Rhodesia (K).

Habenaria **ugandensis** Summerh., Kew Bull. 16: 299. Uganda (K).

Habenaria **unicalcar** Summerh., Kew Bull. 16: 271. Tanganyika, Nyasaland, Northern Rhodesia, Southern Rhodesia (K).

Habenaria **urundiensis** Summerh., Kew Bull. 16: 301. Urundi (K).

Holothrix **tridactylites** Summerh., Kew Bull. 16: 253. Tanganyika, Northern Rhodesia (K).

Ionopsis **longicaulis** L. O. Wms., Brittonia 14: 443. Mexico (F).

Lankesterella **orthantha** (Kränzlin) Garay, Caldasia 8: 521. *Spiranthes orthantha* Kränzlin.

Lepanthopsis **astrophora** (Reichb. f. ex Kränzlin) Garay, Caldasia 8: 520. *Pleurothallis astrophora* Reichb. f. ex Kränzlin.

Lycaste **longipetala** (Ruiz & Pavón) Garay, Caldasia 8: 524. *Maxillaria longipetala* Ruiz & Pavón.

Manniella **americana** Schweinf. & Garay, Bot. Mus. Leafl. 20: 5. Venezuela (NY).

Maxillaria **affinis** (Poepp. & Endl.) Garay, Caldasia 8: 527. *Scaphyglottis affinis* Poepp. & Endl.

Maxillaria **bicallosa** (Reichb. f.) Garay, Caldasia 8: 527. *Zygopetalum bicallosum* Reichb. f.

Maxillaria **bolivarensis** C. Schweinf., Bot. Mus. Leafl. 20: 22. Venezuela (Herb. Univ. de los Andes, Mérida).

Maxillaria **haemathodes** (Ruiz & Pavón) Garay, Caldasia 8: 528. *Fernandezia haemathodes* Ruiz & Pavón.

Maxillaria **sulcata** C. Schweinf., Bot. Mus. Leafl. 20: 4. *Maxillaria rugosa* Schltr., not *M. rugosa* Scheidw.

Monophyllorchis **microstyloides** (Reichb. f.) Garay, Caldasia 8: 517. *Pogonia microstyloides* Reichb. f.

Neobolusia stolzii var. **glabripetala** Summerh., Kew Bull. 16: 255. Southern Rhodesia (K).

Octomeria robusta var. **negrensis** (Pôrto & Brade) Pabst ex Leinig, Orquidea (Bras.) 24: 124. *Octomeria crassifolia* var. *negrensis* Pôrto & Brade.

Octomeria **schultesii** Pabst, Arq. Bot. Est. S. Paulo n. s. 3: 268. Colombia (IAN).

Odontoglossum **confusum** Garay, Die Orchidee 13: 217. *Odontoglossum schroederianum* Reichb. f., 1887, not *O. schroederianum* Reichb. f., 1882.

Odontoglossum **ligulatum** (Ruiz & Pavón) Garay, Caldasia 8: 528. *Maxillaria ligulata* Ruiz & Pavón.

Orchis* **scopulorum Summerh., Bol. Soc. Broteriana 35: 55. 1961. Madeira (K).

Palmorchis **puber** (Cogn.) Garay, Caldasia 8: 518. *Elleanthus puber* Cogn.

Platystele **stenostachya** (Reichb. f.) Garay, Caldasia 8: 520. *Pleurothallis stenostachya* Reichb. f.

Pleurothallis* **butcheri L. O. Wms., Fieldiana: Bot. 29: 346. 1961. Panama (F).

Pleurothallis **cymbicallii** Pabst, Arq. Bot. Est. S. Paulo n. s. 3: 268. Colombia? (IAN).

Pleurothallis **parvilabia** C. Schweinf., Bot. Mus. Leafl. 20: 14. British Guiana (NY).

Pleurothallis **raduliglossa** Pabst, Orquidea (Bras.) 24: 44. *Physosiphon hystrix* Kränzlin, not *Pleurothallis hystrix* Reichb. f.

Pleurothallis **revoluta** (Ruiz & Pavón) Garay, Caldasia 8: 520. *Humboldtia revoluta* Ruiz & Pavón.

Pleurothallis scandens var. **simplicicaulis** C. Schweinf., Bot. Mus. Leafl. 20: 16. Venezuela (AMES).

Sepalosaccus **strumatus** (Endres & Reichb. f.) Garay, Caldasia 8: 525. *Ornithidium strumatum* Endres & Reichb. f.

Spiranthes **calcarata** (Sw.) Jiménez, Phytologia 8: 326. *Neottia calcarata* Sw.

Spiranthes **callifera** C. Schweinf., Bot. Mus. Leafl. 20: 1. Venezuela (NY).

Spiranthes **cordatiloba** C. Schweinf., Bot. Mus. Leafl. 20: 5. *Sarcoglottis tenuis* Schltr., not *Spiranthes tenuis* Lindley.

Spiranthes **goninensis** (Pulle) C. Schweinf., Bot. Mus. Leafl. 20: 3. *Stenorrhynchus goninensis* Pulle.

Spiranthes **laxiflora** (Ekman & Mansf.) Jiménez, Phytologia 8: 326. *Cyclopogon laxiflorum* Ekman & Mansf.

Spiranthes **longiauriculata** C. Schweinf., Bot. Mus. Leafl. 20: 3. Venezuela (AMES).

Stellilabium **helleri** L. O. Wms., Brittonia 14: 443. Nicaragua (F).

Stellilabium **standleyi** (Ames) L. O. Wms., Brittonia 14: 446. *Telipogon standleyi* Ames.

Taeniophyllum **vietnamense** Tixier & Guillaumin, Bull. Mus. Hist. Nat. Paris II 34: 262. Viet Nam (P?).

GENERAL INDEX TO VOLUME L

New scientific names of plants and the final members of new combinations are printed in **bold face** type; synonyms and page numbers having reference to figures and plates, in *italics;* and all other matter, in ordinary type. Names appearing in the *Index of orchid names,* p. 53-54, are not included.

Araceae, 23

Caladiopsis **dodsonii,** 28; Lehmannii, 28
Cook, J., 12, 13
Cotton, early uses in Polynesia, 13; kidney-seeded forms, 8; natural dispersal, 6; New World, 1-3; of Galápagos Islands, 8, 16; Polynesian, 1-22; Polynesian names, 14, 18; presence in Polynesia attributed to three introductions, 19-20; recent introduction in Hawaii, 8; recent introduction in Southern Pacific, 18; Tahitian and Marquesan, 9-11; uses unrelated to fiber, 3; *see also* Gossypium.

Embalming, cotton used in, 13
Epipremnum **aureum,** 28
Ewawei, 9, 12

Gossypium barbadense, 1, 2, 4, 11, 13; barbadense var. brasiliense, 9; darwinii, 8, 16; herbaceum, 13; hirsutum, 1, 2, 4, 11, 15; hirsutum var. punctatum, 10; purpurascens, 10; religiosum, 10; *sandvicense,* 4; taitense, 10; tomentosum, 4-7.

Huluhulu, 4

Lampwicks, 13

Mao, 4, 14, 15
Mendāna, 12, 16

Orchid names, index, 53

Philodendron **barrosoanum,** 23; **dressleri,** 24; **frits-wentii,** 26; **grazielae,** 27
Pothos aureus, 28

Quiros, 16, 17

Seed-fern, 29
Sutcliffia in the American Carboniferous, 29-51; S. insignis var. **tuberculata,** 31, *38-51*

Tinderboxes, 14

Vauvau, vavai, etc., 12-15

Wilkes, C., 13

MISSOURI BOTANICAL GARDEN

STAFF

EDGAR ANDERSON,
Curator of Useful Plants

HENRY N. ANDREWS,
Paleobotanist

HUGH C. CUTLER,
Executive Director

CALAWAY H. DODSON,
Taxonomist and Curator of Living Plants

JOHN D. DWYER,
Research Associate

RAYMOND FREEBORG,
Research Associate

TRIFON VON SCHRENK,
Assistant Curator Museum of Economic Plants

OWEN J. SEXTON,
Research Ecologist

GEORGE B. VAN SCHAACK,
Curator of Grasses and Librarian

† ROBERT E. WOODSON, JR.,
Curator of Herbarium

BOARD OF TRUSTEES

President
HENRY HITCHCOCK

First Vice-President
LEICESTER B. FAUST

Second Vice-President
HENRY B. PFLAGER

HOWARD F. BAER
DANIEL K. CATLIN
SAM'L. C. DAVIS
DUDLEY FRENCH (*Honorary*)
JOHN S. LEHMANN
WARREN McK. SHAPLEIGH
TOM K. SMITH, JR.
HARRY E. WUERTENBAECHER, JR.

EX-OFFICIO MEMBERS

GEORGE L. CADIGAN,
Bishop of the Diocese of Missouri

JOHN J. HICKS
President, Board of Education of St. Louis

STRATFORD LEE MORTON,
President of the Academy of Science of St. Louis

THOMAS H. ELIOT,
Chancellor of Washington University

RAYMOND R. TUCKER,
Mayor of the City of St. Louis

Secretary
WALDO G. FECHNER

† Deceased November 6, 1963.